DEPARTMENT OF TECHNOLOGY
BUFFALO AND ERIE COUNTY PUBLIC LIBRARY

Aeronautical Engineering REVIEW

August, 1955

Controlled

Electrical Noise!

Reliable equipment is needed to simulate the composite vibrations existing in an airplane or guided missile in flight. Such equipment is essential for pretesting airborne equipment while yet on the ground.

North American Aviation's Propulsion and Environmental Laboratories are now looking into the possibility of "shaping" the output of a G-R Type 1390-A Random-Noise Generator to reproduce the frequency distribution of vibrations present in airborne devices. The output of a Random-Noise Generator amplified by a 10-kilowatt high-fidelity amplifier is used to drive an electro-dynamic shaker. By filtering portions of the Noise Generator's frequency spectrum and superimposing with a fixed-frequency oscillator, the dominant frequencies known to be existent in a particular airplane, a reproduction of the vibrations present in flight can be reconstructed.

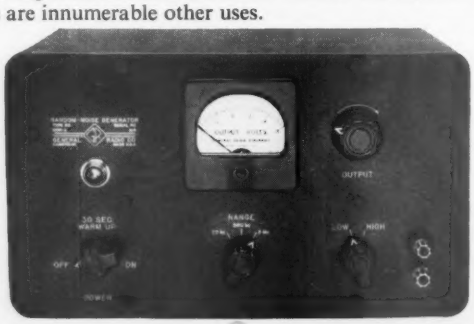
This is another of the many uses for controlled *electrical noise* produced by G-R's Type 1390-A Noise Generator.

Photo Courtesy North American Aviation, Inc.

Since NOISE is a common form of interference limiting the threshold of electrical operation, a Random-Noise Generator can be used to check equipment and systems for susceptibility to such interference. Unlike sine-wave sources, the amplitude distribution of the Random-Noise Generator closely approximates the normal probability distribution curve of speech, music and many other sounds and electrical disturbances which occur naturally. Random noise, for this reason, is useful in a broad field of applications.

The Generator is widely used by manufacturers of radio and television receivers, communications systems and detection apparatus for obtaining a realistic measurement of Noise Figure. The instrument is a great aid in transmission-engineering work involving crosstalk measurements whether the medium is wire, carrier or radio. There are innumerable other uses.

Type 1390-A
Random-Noise Generator . . . . . $240.



Three Frequency Bands: 30 cps to 20 kc, flat to ±1 db; 30 cps to 500 kc, flat to ±3 db; 30 cycles to 5 Mc, flat to ±3 db to 500 kc and to ±8 db above 500 kc.

Output: One volt rms, maximum; accessory Type 700-P1 Voltage Divider provides output levels as low as 0.0001 volt.

Average Spectrum Level: for one-cycle band with one-volt output, 6 mv on 20 kc band, 1 mv on 500 kc band, 0.5 mv on 5 Mc band.

Output Impedance: 800 ohms grounded at maximum output.

We Sell Direct
Prices are net, f.o.b. Cambridge or West Concord, Mass.

GENERAL RADIO Company

275 Massachusetts Avenue, Cambridge 39, Massachusetts, U. S. A.

1915-1955
40 Years of Pioneering in Electronics

90 West Street NEW YORK 6
8055 13th St., Silver Spring, Md. WASHINGTON, D. C.
York Road & Guernsey Avenue, Abington, Pa. PHILADELPHIA
920 S. Michigan Ave. CHICAGO 5
1000 N. Seward St. LOS ANGELES 38

Aeronautical Engineering REVIEW

Vol. 14—No. 8 August, 1955

CONTENTS

Instrument Simplification.....*Comdr. George W. Hoover* 16

The Development of Oil-Cooled Generators.....*O. E. Buxton* 21

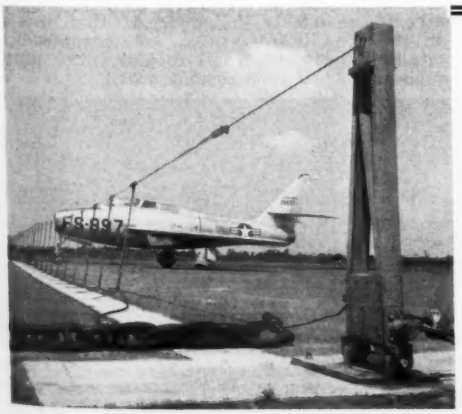
Superperformance Rockets for Fighter Aircraft.....*Robert Gordon* 27

Variable-Stability Airplanes in Lateral-Stability Research.....
.....*William M. Kauffman and Fred J. Drinkwater, III* 29

Simplified Magnesium Air-Frame Design.....*J. P. Donald Garges* 36

High-Altitude Cabin-Pressurization Design Criteria Related to Future Transport Operations.....*L. M. Hitchcock* 44

IAS News..... 9
Editorial..... 14
Special IAS Publications..... 26
IAS Preprints..... 49, 130
Aeronautical Reviews..... 91
Books..... 121
Personnel Opportunities..... 127
Index to Advertisers..... 131
New Products and Product Literature..... 133



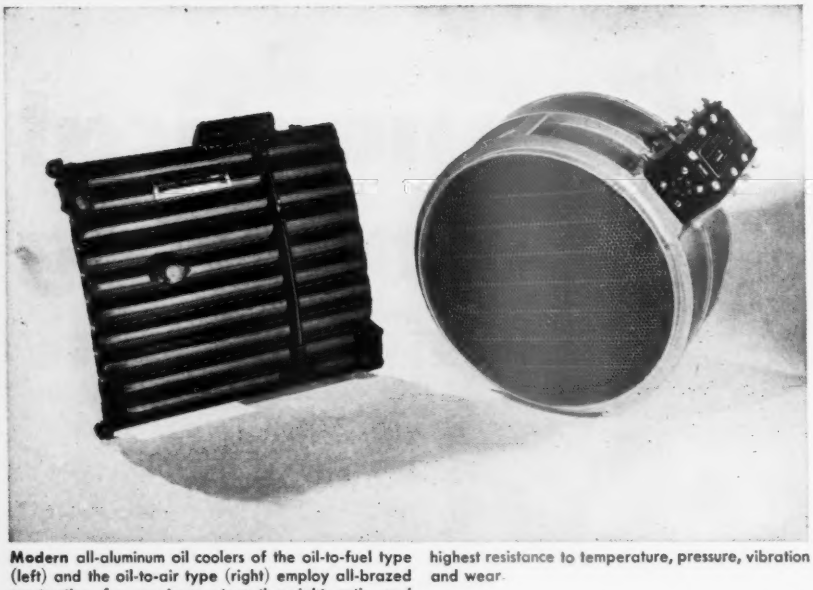
Cover—Three remote-controlled runway crash barriers are in use at Republic Aviation Corporation's airfield at Farmingdale, N.Y., to halt jets that fail to become air-borne or that overshoot the runway. The network of nylon and steel cables is raised by electrical controls that pull up the hinged stanchions. When struck by a plane, the net drags 36 tons of old anchor chains along the ground, checking its speed in about half the usual braking distance. Tests were conducted with a Republic F-84F Thunderstreak (shown) at 150 m.p.h.

Published Monthly by the

Institute of the Aeronautical Sciences, Inc.

2 East 64th Street, New York 21, N.Y.

Western Office: 7660 Beverly Blvd., Los Angeles 36, Calif.



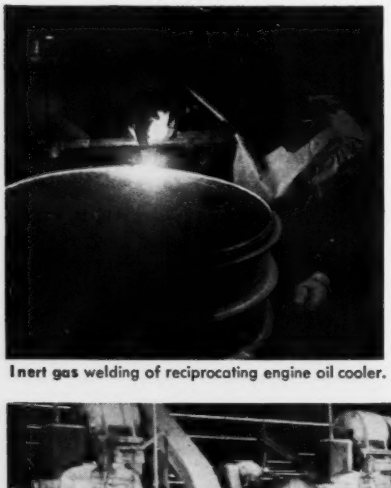
Modern all-aluminum oil coolers of the oil-to-fuel type (left) and the oil-to-air type (right) employ all-brazed construction for maximum strength-weight ratio and highest resistance to temperature, pressure, vibration and wear.

Progress In Oil Coolers . . .

Based on unique, proprietary processes for producing and brazing thin metal sections, plus the largest wind tunnel laboratory facility of its kind, the Clifford Company has pioneered the major developments in this field since 1940.

As flight conditions become increasingly severe with the drive for higher speeds over greater altitude ranges, temperature regulation of engine lubricating oil becomes a critical, sometimes limiting, factor in aircraft capabilities.

The relatively simple requirements of oil cooling in pre-war reciprocating engines, have today become complex heat exchange problems further complicated by the need to provide adequate heat rejection capacity within strict limits of size, weight — and sometimes even shape.



Inert gas welding of reciprocating engine oil cooler.

Three unique assets Clifford brings to bear on aircraft heat exchange problems have been largely responsible for the fact that it has initiated the major advances in the oil cooler field since 1940.

One asset is Clifford's ability to produce and fabricate thin metal sections, based on its own developments in deep drawing and extrusion.

Another is its exclusive proprietary process for brazing thin metals — particularly aluminum — which is unmatched by any other process.

Third is Clifford's wind tunnel laboratory — the largest, most completely equipped technical facility of its kind.

Clifford's background since the company's inception in 1926 was in the manufacture of thin walled metallic bellows and thermostatic assemblies.

Bombsight servomechanism is typical aircraft application of Clifford bellows for automatic compensation of changes in temperature, pressure and other factors.

Typically, it broke into this field by developing the new, superior hydraulic forming method of producing bellows which today is the standard process throughout the world.

Handling thin metal sections to produce products for the control of heat proved excellent basic experience to back up Clifford's entry into the aircraft field.

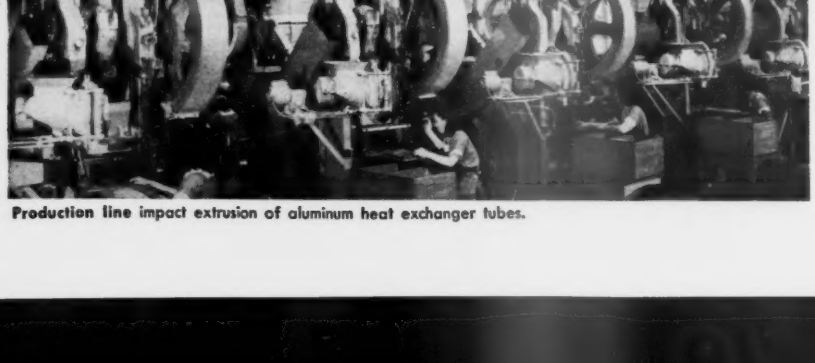
The deep drawing and extrusion process attracted the attention of the armed services in the pre-war preparedness days and Clifford was asked to produce copper tubes for the manufacturers of aircraft oil coolers and coolant radiators.

Once acquainted with the field, it was not long before Clifford's metallurgical background uncovered an area of opportunity. Copper coolers were not wholly satisfactory. The dip soldering method of fastening the tubes so annealed the metal that many failures were experienced at pressures of only 100 psi or less. With oil pressures trending steadily upward in the newer engines, the situation was right for the introduction of a better design if one could be found.

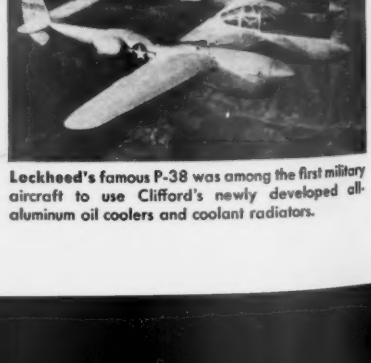
Five years of metallurgical research at Clifford had resulted in a unique, proprietary process for brazing thin aluminum sections. Combining its earlier development in deep drawing and extrusion of thin tubing, Clifford independently designed and produced the first all-aluminum oil cooler and coolant radiator.

The new unit weighed only one-third as much as conventional copper coolers and life cycle tests showed a far higher service expectancy. The air services gave their enthusiastic approval and Clifford found itself in the forefront of a new field.

First to use the new aluminum oil coolers and coolant radiators were the Air Force's P-40 and P-38. Others quickly followed. At the war's end, Clifford was the sole producer of all-aluminum oil coolers whose products had been combat tested.

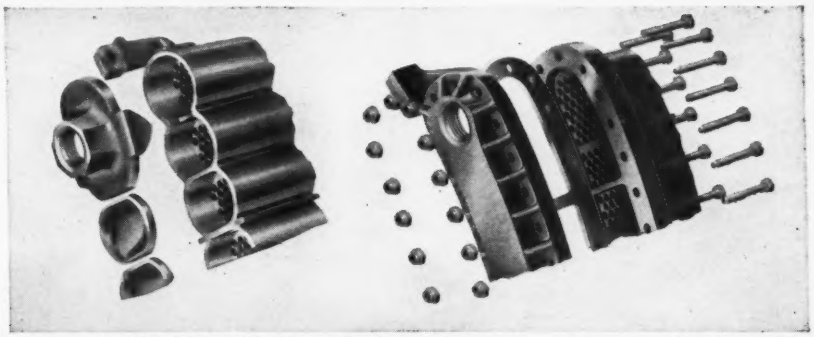


Production line impact extrusion of aluminum heat exchanger tubes.



Lockheed's famous P-38 was among the first military aircraft to use Clifford's newly developed all-aluminum oil coolers and coolant radiators.

Coolant radiator of the type used in wartime liquid-cooled reciprocating engines.



Advanced, simplified design of liquid type oil cooler for jet engines (left) shows obvious advantages over original design pioneered by Clifford. Gaskets, bolts and nuts are eliminated, weight reduced 28%, and a stronger, unitized, all-brazed construction achieved.

Early jet engines coming along after the war required no oil cooling device. Oil was simply sprayed on the bearings and then ejected overboard. But with General Electric's contract to produce the J47-C, Clifford was asked to develop a suitable cooling system.

A completely new concept of oil cooling was suggested by Clifford. Since jets consumed large amounts of fuel it was possible to pass cold fuel on one side of the heat exchanger, hot lubricant on the other. With the flow governed by thermostatic valves, the lubricating oil is kept at optimum temperature.

The new design, since it did not depend on ram air for cooling, could be mounted out of the air stream and more easily armored. These and other advantages caused it to be adopted as standard for military jet aircraft.

Later improvements resulted in substantial weight reduction and the elimination of numerous parts. Employing an extruded aluminum shell fastened by its proprietary brazing process, Clifford is today the only company able to produce these superior all-brazed, all-aluminum oil coolers.

Clifford's wind tunnel laboratory plays an increasingly important role in keeping the company in the forefront of aircraft heat exchanger developments. Ability to simulate service conditions with great accuracy eliminates the need for time consuming, expensive field testing of new designs. Its vast store of empirical knowledge permits rapid translation of thermodynamic theory into practical design without need for a succession of pilot models.

In few companies is there such a direct linear connection between research and production as can be found at Clifford.

New developments, still under military or proprietary wraps include a new oil cooler design based on using the latent heat of vaporization to cool the oil and vaporize part of the fuel before it enters the combustion chamber.

Sikorsky's H-39 helicopter which recently established a world's speed record, carries a Clifford oil cooler.

A great reduction in weight and bulk is achieved.

Another involves a special oil cooler for afterburners which automatically cuts in and out with the operation of the afterburner.

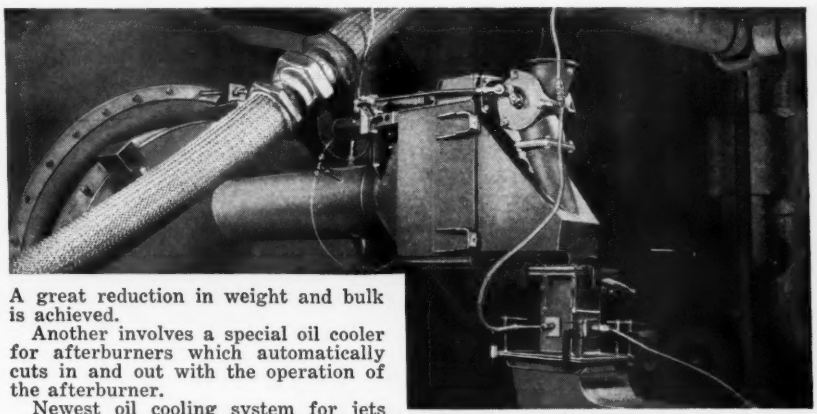
Newest oil cooling system for jets takes care of "high altitude cooling" conditions. When fuel flow drops too low to provide adequate cooling, thermostatic valves cut in an auxiliary air type cooler.

Helicopters pose especially difficult problems. Changes in direction from horizontal to vertical flight — or to hovering — makes their oil cooling demands highly variable. Clifford is currently developing two answers to these problems. One is an air-type cooler placed in an eductor. Engine exhaust is used to induce a flow of air for cooling. The second employs an air-type cooler placed in the air stream, but having in integral fan driven by a fluid motor. Oil temperature determines the operation of the fan through the action of thermostatic valves.

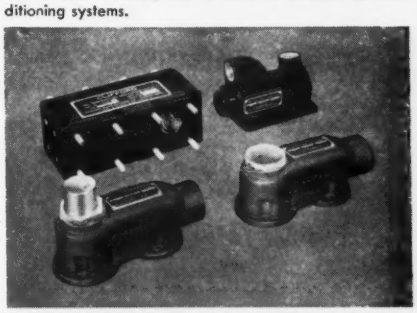
Rockets, missiles and avionic equipment are other areas in which Clifford is working. The company is also deep into nuclear energy heat exchange involving the handling of molten metals.

In all these areas, Clifford's unmatched facilities in aircraft heat exchange; and its unique ability to produce, fabricate and braze thin metal sections by proprietary processes is largely responsible for its present leadership in aircraft heat exchanger design.

For further information write: Clifford Manufacturing Company, 175 Ipswich St., Boston 15, Mass. *Division of Standard Thomson Corporation.* Offices in New York, Detroit, Chicago, Los Angeles and Waltham, Mass.



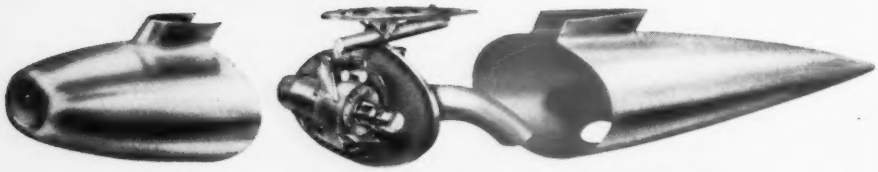
Wind tunnel test of air-to-air type heat exchanger assembly. Unit shown has integrally mounted control valves and actuator, and is used in aircraft air conditioning systems.



Self contained oil temperature regulating valves are designed and manufactured by Clifford for oil cooler applications.

Installation of oil-to-fuel type oil cooler on turbo-jet engine.

Bellows And Bellows Devices
CLIFFORD MANUFACTURING CO. WALTHAM, MASS.
Aircraft Heat Exchangers Valves Electronic Equipment



Solar research boosts altitude power output of gas turbine generator sets

FLYING ELECTRONIC TEST-BEDS need plenty of power in flight. So Solar "Mars" gas turbine auxiliary power units have been ordered for the Convair C-131B. Two APU's, each hung in a pod, will be installed on each plane.

With the Solar units, an ample and versatile supply of electricity is assured. The easily demountable gas turbine driven generators can both be direct current units, or both alternating current, or one of each can be installed. *As much as 30 kw d-c, or 40 kva a-c, can be supplied at 25,000 feet.* This high power output results from major design improvements in the proven Mars engine.

Mars gas turbine APU's are already specified equipment on the Douglas C-124C and the Lockheed C-121C. They have demonstrated their reliability and trouble-free service life by logging thousands of hours with only routine maintenance. Recently these Solar units were uprated from 500 hours to 750 hours between overhauls.

Light, compact Mars APU's can solve your airborne power needs. Write to Solar today for more information about these remarkable gas turbine generators!

SOLAR AIRCRAFT COMPANY — SAN DIEGO, DES MOINES

ENGINEERS WANTED. *Unlimited opportunities in Solar's expanding gas turbine program! Write today, giving your experience, to the address in the coupon.*

This is What Solar Offers You

When heat, corrosion or difficult specifications are problems, Solar can help you solve them. Solar specializes in the manufacture of precision products from alloys and special metals for severe service. Solar's experience since 1927 is unduplicated in this field.

SPECIAL PRODUCTS

Gas Turbines. *Solar "Mars" 50 hp engines for auxiliary generator sets, ground carts, portable fire pumps; Solar "Jupiter" 500 hp engines in variable and constant speed models.*

Bellows. *"Sola-Flex"® bellows and expansion joints in many designs from ½ in up to the world's largest, 28 ft in diameter.*

Controls. *Complete control systems utilizing the new Solar "Microjet"® principle for control of gas turbines, jet engines and pneumatic devices.*

CONTRACT PRODUCTION

Current orders include aircraft engine and airframe parts, pneumatic ducting, atomic energy components. Customers include the finest aircraft and industrial companies in the U.S. and Europe.

Plants. *In San Diego (photograph above) and Des Moines. A total of 1,400,000 sq ft of floor space. Approximately 5,000 employees. Annual sales over $65,000,000.*

Services. *Research, design, development and production engineering staffs. Experienced with all alloy steels, stainless alloys, super alloys, and titanium and its alloys.*

Facilities . . . *for all types of metal fabrication—forming, machining, welding, brazing, casting, coating. Equipped for prototype, limited or mass production. Extensive laboratories. Complete quality control.*

INFORMATION

For more information regarding Solar Gas Turbines or any Solar product or service listed above, write Solar Aircraft Company Department B-44 San Diego 12, California

IAS News

A Record of People and Events of Interest to Institute Members

Bane and Chanute Awards Presented

WADC Commander and WADC Scientist Are Given 1955 Honors at Los Angeles Meeting

MAJOR GENERAL ALBERT BOYD, Commander of Wright Air Development Center of the Air Research and Development Command of the Air Force, and K. Gottfried Guderley, a civilian scientist employed at WADC, have received 1955 honors from the Institute of the Aeronautical Sciences for their notable work in advancing aeronautics.

The Thurman H. Bane Award was presented to Mr. Guderley and The Octave Chanute Award was made to General Boyd on June 23 at a dinner dance in Los Angeles marking the close of the Fifth International Aeronautical Conference sponsored by the IAS and the Royal Aeronautical Society. An Honorarium of $200 accompanied each certificate.

▸ **The Bane Award,** given each year to an officer or civilian of the USAF Air Research and Development Command for an outstanding achievement in aeronautical development, was presented to Mr. Guderley for "his outstanding contributions to the development of transonic aerodynamics essential to the engineering design of supersonic aircraft." Mr. Guderley, a German scientist who came to the United States in 1946 at the invitation of the U.S. Air Force, is in the Applied Mechanics Branch of the Aeronautical Research Laboratory of WADC at Wright-Patterson Air Force Base, Ohio.

His publications on the theoretical aspects of mixed flows with subsonic and supersonic regions provide a basis for the theoretical understanding of the aerodynamic problems associated with breaking the so-called sonic barrier. The discovery of the transonic similarity laws by Mr. Guderley and by Theodore von Kármán, working independently, was the most important contribution made thus far to a basic understanding of the aerodynamics of mixed subsonic and supersonic flows.

Mr. Guderley proved that it would be impossible to produce shock-free transonic designs, thus calling a halt to extensive experimental programs. He has examined in great detail the transonic flows over specialized bodies. He helped solve the problem of "choking" in transonic wind tunnels.

This award, endowed by Major R. H. Fleet, honors the memory of Col. Thurman H. Bane of the U.S. Army Air Corps who died in 1932.

▸ **The Chanute Award,** given annually for a notable contribution made by a pilot to the aeronautical sciences, was presented to General Boyd for "major contributions to the aeronautical sciences through improvements in the techniques of flight testing, the development of facilities for flight testing, and the evaluation of large numbers of military aircraft."

General Boyd has been personally associated with experimental test flying for 10 years. He has flown all the jet aircraft of the USAF and numerous prototypes of possible interest to NATO. He is the only general officer who has test flown the "X" series of transonic and supersonic research airplanes.

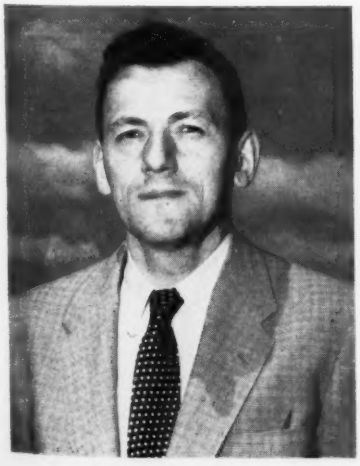
He has test flown a number of foreign military planes, including the MiG-15.

Before taking charge of WADC in 1952, General Boyd was Commander of the Air Force Flight Test Center at Edwards AFB, Calif. Under his direction, the AFFTC underwent a major reorientation and expansion. There were marked improvements in the caliber of test pilots and in instrumentation, flight-test planning, and execution.

As Commander of WADC, he now directs a major portion of the Air Force research and development program, including weapon system projects.

In 27 years with the Air Force, General Boyd has logged 11,000 hours in the air and has become known as "a test pilot's test pilot." He has established several speed records, including one of 623 m.p.h. in an F-80R in 1947.

The Octave Chanute Award honors the American pioneer in experiments with gliders, who died in 1910.



K. Gottfried Guderley

Major Gen. Albert Boyd

Conferences on Aeronautical Electronics and Telemetering Draw IAS Engineers to Dayton and Chicago

In line with its policy of joining other engineering societies in sponsoring meetings of mutual interest, the Institute of the Aeronautical Sciences participated in two cooperative meetings in May: The National Conference on Aeronautical Electronics and the 1955 National Telemetering Conference.

Both national meetings underscored the importance of the rapidly expanding electronics industry and the close working relationship that must be maintained between the electronics engineer and the aeronautical engineer. A number of papers were presented by IAS members.

To a large extent, modern air warfare has become a duel in electronics. Often more than half the cost of air weapons lies in the electronics portions. The further development of guided missiles will emphasize this trend.

The Conference on Aeronautical Electronics, held May 9–11 in Dayton, Ohio, attracted a registration of more than 1,300. The program included the presentation of 119 technical papers, as well as luncheons, a dinner dance, and manufacturers' exhibits. Several social events were arranged for wives of delegates.

This conference was sponsored by the Dayton Section of the Institute of Radio Engineers and the IRE Professional Group on Aeronautical and Navigational Electronics. The IAS cooperated in the presentation of technical papers. George J. McTigue, Chairman of the Dayton Section of IAS, led a group of Dayton members participating in committee work.

Lewis M. Hull, AFIAS, Chairman of the Board, Aircraft Radio Corporation, won the annual Pioneer Award given by the Conference. He was cited as a pioneer investigator of the principles of wave propagation to and from aircraft who during the early days of military aviation assisted in the development of an air-borne spark transmitter for the Signal Corps and adapted military receivers for use on aircraft in connection with Kolster localizer system development. Mr. Hull has been awarded some 20 patents for investigations dealing with methods, materials, and apparatus for aeronautical radio transmission and reception.

The award was presented at the Annual Banquet in the Biltmore Hotel. The guest speaker was R. H. Puffer, Superintendent of Cornell Aeronautical Laboratory, Inc. A humorist and philosopher, he gave an entertaining talk that he called "My Sixty Years Before the Mast."

The National Telemetering Conference, held May 18–20 at the Morrison Hotel, Chicago, drew more than 400 members of the American Institute of Electrical Engineers, Instrument Society of America, IRE, and IAS—the joint sponsors. In 3 days of technical session, 39 papers were presented dealing with Industrial Telemetering, Pick-Ups and Transducers, Flight Testing, Data Processing, Multiplexing Techniques, and New Developments in Telemetry and Remote Control.

For the first time, the Proceedings of the National Telemetering Conference—compiled this year by the IAS—were printed in advance and sold at the Conference. Additional copies of this book, which contains the complete 1955 papers, may be obtained at $3.50 by writing to the IAS Publications Department, 2 East 64th St., New York 21, N.Y.

Much of the credit for early compilation of the Proceedings and for the excellent program belongs to Conrad H. Hoeppner, Chairman of the Program Committee, and Harvard L. Hull, AFIAS, Vice-Chairman of the Conference Committee.

William A. Wildhack, of the National Bureau of Standards, spoke at the luncheon May 20. His topic was "In-Accurate Transmission of Mis-Information."

The speaker at the Annual Banquet was Hugh L. Dryden, Director of the National Advisory Committee for Aeronautics and Past-President of the IAS.

The fact that a musket ball traveled faster than the report of the gun from which it was fired was observed more than 300 years ago, Hugh Dryden remarked in opening his address on "Problems in Ultra-High-Speed Flight." Projectiles weighing more than a ton have been fired from guns at supersonic speeds.

"The basic power plant of today's supersonic tactical airplane," he said, "is the turbojet equipped with afterburner.

"In the ultra-high-speed region, the ram-jet and rocket engines will surely come into the picture at some stage, but developments in the turbojet engine have made it the preferable power plant to speeds much higher than were once thought possible. In general, there is no limitation of speed foreseen due to insufficient power, although the required power plants may not now be available."

Although wind tunnels have been built to operate at ten times the speed of sound, Dryden said the NACA prefers to use rocket-propelled models for much of its research at the higher supersonic speeds. Telemetry makes it possible to obtain test data directly from the flying model.

"Recent talk of a 'stability barrier' is misleading," continued the speaker, "because there is no fixed value of speed at which the stability suddenly deteriorates. Research has produced configurations for which the changes in stability and trim in passing from subsonic to supersonic speeds are relatively small.

"Aerodynamic heating creates difficult problems for the designer, because it may reduce stiffness of the metal structure to the point where destructive flutter will occur. The study of flutter provides a fertile field for instrumentation development.

"As man pushes on toward ultra-high-speed flight, he has failed to produce a corresponding ultra-man. His vision becomes inadequate and must be extended by electronic means. His muscular strength must be supplemented by power-boost controls with built-in 'feel.' These efforts to provide man with the means to fly his new airplanes at ultra-high speeds inevitably lead to complexity."

IAS Electronics Session Planned for WESCON

The San Francisco Section of the IAS is cooperating with representatives of the Institute of Radio Engineers and the West Coast Electronics Manufacturers Association in arranging a session on the application of electronics to aircraft testing and evaluation. This session will be held during the annual Western Electronic Show and Convention scheduled for August 24–26 in San Francisco.

Smith J. DeFrance, Director of Ames Aeronautical Laboratory, NACA, will preside at the session. Ernest G. Stout, Staff Engineer of Convair, A Division of General Dynamics Corporation, will discuss the use of electronics in dynamic similar model testing. Richard F. Gompertz, Chief of the Rocket Engine Test Laboratory at the Air Force Flight Test Center, Edwards AFB, will speak on electronics in rocket test operations. W. L. Howland, Division Engineer—Flight Test, of Lockheed Aircraft Corporation, will describe the role of electronics in flight testing. Ames Laboratory has agreed to provide a speaker on the topic of electronics in flight-test research.

NADMC Conducts Johnsville Tour for IAS Members

Forty-nine IAS members and representatives of Corporate Members visited the U.S. Naval Air Development and Material Center at Johnsville, Pa., May 24–25, at the invitation of Rear Adm. Selden B. Spangler, Commander.

The secret field trip consisted of tours of the Naval Air Development Center and the Naval Air Turbine Test Station, explanatory talks and displays, and a number of technical talks by Naval officers and civilian scientists working on current research projects.

Including a dinner and evening session, the program ran a day and a half.

The visitors saw the NADC's Aeronautical Electronic and Electrical Laboratory, Aeronautical Instruments Laboratory, Aeronautical Photographic Experimental Laboratory, Analytical and Computer Department, Aviation Armament Laboratory, Aviation Medical Acceleration Laboratory, and Engineering and Development Services Department. At NATTS, in Trenton, N.J., they saw the Aeronautical Turbine Laboratory.

The Naval Air Material Center, located at the Philadelphia Naval Base, was represented by five speakers on timely topics, but the group did not visit NAMC. The tours were arranged for familiarization and background knowledge.

Those who attended the field trip were conducted in four small groups. Shown in the upper left photo is the group led by Admiral Spangler, which included Dogan H. Arthur, Thomas Carrol, Gorgon Earl Collins, G. William Ehreke, Jr., S. Paul Johnston, Hans W. Kretsch, Thomas J. Meskel, Paul Rosenberg, Edward R. Sharp, Robert M. Stanley, Charles Tilgner, Jr., and Rear Adm. Henry G. Williams, USN (Ret.).

In the upper right photo are Herbert L. Bansbach, Capt. Ralph S. Barnaby, USN (Ret.), K. C. Black, Eric A. Corkhill, Karl J. Fairbanks, Richard Hodgson, Carl W. Lemmerman, Arthur P. G. McGinnes, Jr., Howard F. Powders, Michael Stroukoff, and Capt. J. A. Haley, Commanding Officer of NADC, and Lt. Comdr. R. S. Stockwell.

The group at lower left, led by Lt. Comdr. J. F. Grosser, consisted of Robert R. Dexter, Sherman M. Fairchild, R. P. Kroon, Thomas W. Meeder, George A. Page, Jr., W. D. Paxson, Charles G. Sage, and Alexander Zeitlin.

In the lower right photo are Welcome W. Bender, Fredric Flader, Edward G. Haven, Roger Wolfe Kahn, John King, John A. Lauck, Joseph J. Maitan, F. E. Moskovics, Elmer A. Sperry, Jr., Carl Sundberg, and Lt. E. E. Achberger, tour guide.

IAS Pays Tribute to Major Reuben H. Fleet

Reuben Hollis Fleet, pioneer aircraft manufacturer and Past-President of the Institute of the Aeronautical Sciences, was honored for his long service to the IAS and the aviation industry at the close of the Fifth International Aeronautical Conference in Los Angeles.

After the Bane and Chanute Awards had been presented at the dinner dance in the Hollywood Palladium, President Robert E. Gross called Major Fleet forward to receive a "classified" award that had not been announced in advance. The move apparently caught the Major by surprise.

Mr. Gross presented to him a Certificate of Appreciation inscribed:

"The Officers and Council of the Institute of the Aeronautical Sciences honor Reuben H. Fleet for his lifelong contribution to aviation, and for his continuing interest in and his many contributions to this Institute as a Founder Member, Benefactor, and Past-President.

"In appreciation of his achievements, this Testimonial is tendered on this twenty-third day of June, 1955."

The certificate was signed by Mr. Gross, S. Paul Johnston, and Robert R. Dexter.

Major Fleet, who served as President of the IAS in 1944, was active for many years in raising funds for the young engineering society. The modern IAS Buildings in San Diego and Los Angeles and the handsome IAS Headquarters in New York (a former Fifth Avenue mansion) are monuments to his fund raising efforts. In addition to contributing his boundless energy and persuasive powers, Major Fleet has made large personal gifts to the IAS Endowment Fund.

Thirty years old when the United States entered the First World War, he joined the aviation section of the Army Signal Corps in 1917, learned to fly, and was commissioned as a pilot. He soon became Executive Officer in Charge of Training in the office of the Chief of the Air Corps in Washington. In 1918 he was placed in charge of the experimental air-mail service between New York and Washington, and he flew the first mail plane to open the route.

Later, as Contracting Officer of the Air Corps, Major Fleet handled airplane contracts involving the expenditure of millions of dollars.

In 1923, a few months after resigning from the Army Air Corps, Major Fleet organized Consolidated Aircraft Corporation with a capitalization of $25,000. Under his leadership, the company prospered with military contracts, and in 1941 Major Fleet sold his holdings for approximately $10,000,000.

Reuben H. Fleet

He was retained as a consultant for 5 years by the successor company, Consolidated Vultee Aircraft Corporation, which later became Convair, A Division of General Dynamics Corporation.

During World War II, Major Fleet was influential in forming the policy of the federal Government toward the aircraft industry.

Now retired from business, he lives in San Diego.

Memorial to Air-Mail Pilots

A plaque honoring the first air-mail pilots was unveiled May 25 at Belmont Park, Long Island, N.Y., by Air Force Secretary Harold E. Talbott, HMIAS.

Sponsored by the Air Mail Pioneers, the tablet was donated by Grover Loening, FIAS, whose services had been enlisted by the early Air Mail Service when pilots encountered difficulty in trying to fly over the Rocky Mountains. As technical adviser, Mr. Loening overcame the ceiling limitation of the airplane by redesigning the wing. The plaque reads:

"To honor pioneers of civil aviation—the first pilots to fly the air mail in the United States.

"From 1918 through 1919, these pilots used Belmont Park for the origin and destination of the first air mail flown between New York and Washington. Thus began the vast network of United States civil aviation."

Among seven names inscribed on the tablet is that of Major R. H. Fleet, AMIAS, Air Service Officer in Charge, who flew the first mail plane on May 15, 1918.

Meeting on Pilot Escape

A symposium on "Escape from High-Performance Aircraft" will be held at the IAS Building in Los Angeles, October 7, under auspices of the Aero-Medical Engineering Association. Co-sponsors will be the Los Angeles Section of IAS and the Institute of Transportation and Traffic Engineering of the University of California.

The all-day program will include a dinner and a round-table discussion in the evening. Nationally known authorities on the subject will discuss methods of escape, designing for protection, personal equipment for protection, and the physics, physiology, and psychology involved. Case histories of actual escapes under emergency conditions will be presented.

John R. Poppen, M.D. (AF), of Northridge, Calif., is Chairman of the Committee.

Winder Aircraft Corporation a New Member of Institute

The Winder Aircraft Corporation, of Lakeland, Fla., has joined the IAS as a Corporate Member.

The company was organized after World War II by Joel T. Henry and Inslee M. Johnson in Winder, Ga., with an office in Atlanta. It commenced operations in the field of manufacturing aircraft components of a technical and precision nature. After several years, the overall planning was modified to include the engineering and manufacturing of electronic products.

As a result of its electronics business, the firm became interested in the research and development of a complete guided missile and has continued its efforts in this field.

About 2 years ago, a department was formed to develop a new type of helicopter with emphasis on a commercial version that could be adapted for military use.

Having limited facilities at the time, the Winder Aircraft Corporation purchased a large tract of land at Drane Field, near Lakeland, early in 1955. The purpose was to obtain adequate land on which to erect a new and modern building to be used for manufacturing and research. Another facility has been acquired at Lodwick Airport, Lakeland, and is being used to manufacture electronic equipment for the Air Force, Army, Navy, and commercial firms here and abroad. Winder's Washington office is at 4201 Massachusetts Ave., N.W.

Helicopter Society to Meet

The American Helicopter Society has scheduled its Second Annual Western Forum for September 21–22 in Los Angeles. There will be 2 days of technical sessions and a trade exposition in the Hollywood Roosevelt Hotel.

Air-Line Safety Records

Thirty-nine scheduled air lines have won the Aviation Safety Award of the National Safety Council for going through the year 1954 without a passenger or crew fatality in air accidents. Among them were five Corporate Members of the IAS: American Airlines, Inc., Eastern Air Lines, Inc., Pan American World Airways, Inc., Trans World Airlines, Inc., and United Air Lines, Inc.

Necrology

Charles H. Day

Charles Healy Day, AFIAS, retired aeronautical engineer, died May 26 at his home in Pacific Palisades, Calif. He was 70.

A pioneer in the aircraft industry and an early member of the IAS, Mr. Day in 1909–1910 designed, built, and flew a tractor biplane with a five-cylinder motor of his own design and manufacture.

The next year he designed and built pusher biplanes at Santa Ana, Calif., with Glenn L. Martin, and in 1912 he opened his own airplane factory in Los Angeles. Selling his assets to The Glenn L. Martin Company in 1913, he joined Martin as Chief Engineer. Subsequently he was Vice-President and Chief Engineer of Standard Aircraft Corporation of Plainfield and Elizabeth, N.J., then the second largest aircraft manufacturer in the country.

In 1931 Mr. Day designed and built an experimental light plane that he flew around the world with his wife, Gladys MacCleary Day. She wrote an illustrated account of the 7-month trip which appeared in the June, 1932, issue of the *National Geographic Magazine*.

During World War II, Mr. Day served as a major with the U.S. Air Force. In 1934 to 1940 he was an adviser to the Nationalist Chinese government, directing the manufacture of airplanes under frequent bombardment. Later he was supervisor of aircraft production for the Canadian government, and from 1942 to 1944 he was manager of Glenn L. Martin's modification plant at Omaha, Neb.

A native of Salamanca, N.Y., Mr. Day was a graduate of Rensselaer Polytechnic Institute. He was a member of the Early Birds and the Quiet Birdmen. His widow survives him.

News of Members

▸ **J. L. Atwood** (F), President of North American Aviation, Inc., and Past-President, IAS, received the honorary degree of Doctor of Engineering from Stevens Institute of Technology on June 11.

▸ **James D. Church** (AF), Aeronautical Research Scientist in the Pilotless Aircraft Research Division, Langley Aeronautical Laboratory, NACA, was awarded a Master of Science degree by the University of Virginia June 12. He is Vice-Chairman of the Hampton Roads Section.

▸ **Don K. Covington, Jr.** (M), Sales Manager, The Harbor Sales Company, Inc., was recently elected a Director of the Sales Executives Council of the Baltimore Association of Commerce.

▸ **Henry Görtler** (M), Professor and Director of the Mathematical Institute of the University of Freiburg, Germany, has been elected President of the German Society for Applied Mathematics and Mechanics (GAMM).

▸ **Gloria W. Heath** (TM), Executive Assistant to the Managing Director, Flight Safety Foundation, Inc., has been awarded the Lady Grace Hay Drummond-Hay Memorial Trophy "for distinguished service in the field of air safety." A former WASP, Miss Heath has been with Flight Safety Foundation since 1948.

▸ **Edward H. Heinemann** (F), Chief Engineer of Douglas Aircraft Company's El Segundo Division, has been awarded a Paul Tissandier Diploma by the Fédération Aeronautique Internationale for "serving the cause of aviation by his work, initiative, and devotion." He also has been named an Honorary Fellow and Life Member of the Society of Aeronautical Weight Engineers, Inc.

▸ **Kenneth R. Herman** (M), Executive Vice-President, Vickers, Inc., has been selected Second Vice-President of The Engineering Society of Detroit.

▸ **Jerome C. Hunsaker** (HF), of Massachusetts Institute of Technology, Chairman of the National Advisory Committee for Aeronautics, was given the honorary degree of Doctor of Science by Adelphi College on June 15.

Southern California's "Aviation Man of the Year" award is presented to Clarence M. Belinn, MIAS *(left)*, by Edward H. Heinemann, FIAS, last year's winner. Mr. Belinn, President of Los Angeles Airways, was honored for advancing commercial use of helicopters.

▸ **Jerome Lederer** (F), Managing Director of the Flight Safety Foundation, Inc., has been presented an illuminated scroll of the "Air Transport Pilots' Code" by Col. Robert F. David, of the Military Air Transport Service. It was adapted from "The Code of the Pilot," written by Mr. Lederer. Lieutenant Gen. Joseph Smith, Commander of MATS, thanked Mr. Lederer for "crystallizing an overdue approach toward a professional pilot attitude."

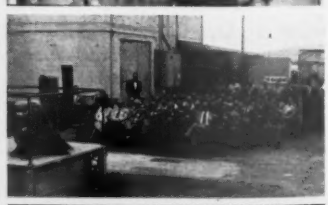
▸ **William Littlewood** (F), Vice-President of American Airlines, Inc., is the new Vice-Chairman of the Industry Advisory Committee of the Flight Safety Foundation. He also was elected recently to represent the alumni on the Board of Trustees of Cornell University.

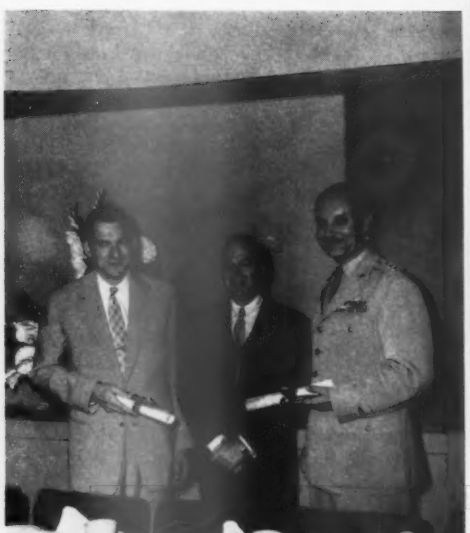
▸ **Maurice Nelles** (M), Director of Research and Diversification, Technicolor Motion Picture Corporation, Hollywood, received an honorary degree of Doctor of Science June 6 from the University of South Dakota. Now working on the development of color motion pictures and color TV, Mr. Nelles has distinguished himself as a scientist in several other fields, including the aircraft, automotive, oil, cement, and chemical-dye industries.

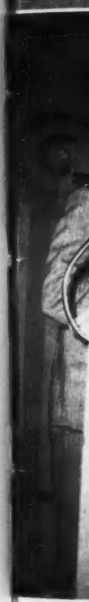
▸ **Andrew P. Papanek** (TM), Manager of the Special Projects Section, Jack & Heintz, Inc., has won a $150

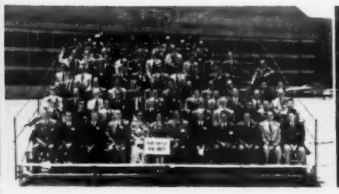
(*Continued on page 50*)

Fifth
TERNATIONAL AERONAUTICAL CONFERENCE









Editorial

FIFTH INTERNATIONAL CONFERENCE

TO THOSE of us who were close to it, the fact that the Fifth International Conference has come and gone scarcely seems possible. We have lived with it for a long time. But the months of planning and careful coordination that went into the project from both sides of the Atlantic and on the West Coast paid handsome dividends. The operation went off without difficulty.

And it *was* quite an operation. Nearly 150 visitors from overseas arrived on schedule (June 18–19) and found well-oiled machinery ready to receive them. Our local committees had done a magnificent preparatory job and carried on their good work in taking care of delegates' requirements for food, housing, and entertainment. For two full weeks there was never a dull moment. When the final curtain was rung down in San Francisco on the evening of July 2, there was no doubt that the Conference had been a complete success.

Highlights, of course, were the technical sessions. The nineteen papers were ably presented and well discussed. It was regretted only that time for discussion had to be curtailed in many cases to maintain a schedule. This suggests that, for meetings of this caliber, not over two papers should be given in any 3-hour session.

Following past conferences, we have complained editorially of the inadequacy of the American discussion vis-à-vis the British. This time, however, the balance was far better. In most of the sessions, the American commentators held their own.

A subsequent issue of the REVIEW will carry a survey of the technical portions of the Conference, and it is planned that the full proceedings, papers, and discussions will be published in a single volume at a later date.

Following the conference sessions, the British Delegation was given the full treatment by West Coast industry and Government activities. Group visits were made at Convair, Ryan, Solar, and Rohr in San Diego and at Douglas, Lockheed, North American, Northrop, Marquardt, Aero-Jet, Zenith Plastics, Harvey Aluminum, CalTech, and Chevrolet in the Los Angeles area. The final touches were applied by the Air Force and NACA, with notable full day demonstrations at Edwards Air Force Base and at Ames laboratories.

We cannot express our thanks too strongly to all of those—individuals and organizations alike—who worked long and hard to make the Conference a success. The Institute is fortunate indeed in counting among its membership so many who are willing to contribute their time and their energy to advance its objectives. S.P.J.

INSTRUMENT SIMPLIFICATION*

COMDR. GEORGE W. HOOVER†
Office of Naval Research, Department of the Navy

Development of a method for obtaining an effective display of orientation instruments, determined by objective criteria rather than personal opinion.

I SHOULD LIKE TO OPEN this paper with a quotation by Abraham Lincoln: "Before we decide what to do, let us find out where we are and where we want to go."

This statement, although made at the time in reference to the State of the Union, can be just as appropriately used as a guide for research and development leading to instrument simplification.

I shall attempt in this paper to establish what I believe should be done about aircraft instruments, first by determining where we are—or rather the state of the art of a part of instrumentation today—and then by trying to establish a direction in which to go in future research and development in this field. I shall further attempt to describe a methodology for instrument design in which personal opinion is kept to an absolute minimum.

Let us start by asking why we have aircraft instruments. Actually we have them for two reasons: The first is in order to operate our aircraft, an extremely complicated device requiring much information of a quantitative nature in order to keep functioning properly. The second is because Mother Nature does not always see fit to provide clear weather, and at times our vision outside the cockpit is obscured, forcing us to utilize other means for orientation (Fig. 1).

For clarification I would like further to divide instrumentation into three broad areas. The first we will call orientation, or instruments to tell us *what we are doing;* the second we will call director, or instruments to tell us *what to do;* and the third we will call quantitative, or instruments to tell us *how* we are doing it (Fig. 2).

Space will not permit a discussion of all three categories so I will cover only the case of orientation.

Most flight instruments today which are used primarily for orientation have been developed by creative engineering and have attempted to simulate certain visual cues. With few exceptions, these instruments have at best been purely symbolic and have required the reconditioning of reflexes on the part of the pilot.

Although this type of display has been a definite aid to flying under instrument conditions, there are certain facts that indicate rather emphatically that present instrument displays are not adequate to fulfill their design objective.

It is well known that present instrument systems require extensive initial training, as well as continuous refresher training, to develop and maintain the proficiency of all pilots. This training is not only expensive but time consuming as well.

We know from both military and commercial records that normal air operations are seriously curtailed during inclement weather conditions. Observe any airfield when weather conditions are marginal, and this will be apparent.

Newspaper files are literally filled with accounts of aircraft accidents attributed mainly to adverse weather conditions, and, oddly enough, most of the pilots were considered fully qualified to fly under instrument conditions.

The very fact that instrument cards, or licenses, must be renewed each year is sufficient to indicate that flying "on instruments" is not something that we can learn once and retain indefinitely.

One other fact that is significant is the continuous controversy over standardization of the instrument arrangement itself. There is no universal standardized arrangement of the instruments and there probably will not be until the instruments themselves are adequate enough to become standardized.

The foregoing statements are made merely to establish the fact that, even though we have made tremendous advances in the state of the art of instrumentation, the data presented to the pilot today is a long way from being sufficient to meet his needs.

One of the real hindrances to good instrument design is the emphasis placed on personal opinion. The fact that a pilot has flown several thousand hours or an engineer has worked on instrument development for 10 years does not in itself make either of them qualified to determine the *type of indication* needed on the instrument panel. The pilot can very definitely tell us what

Presented at the Instrument Systems and Simplification Session, 23rd Annual Meeting, IAS, N.Y., Jan. 24–27, 1955.

* Opinions or conclusions contained in this report are those of the author. They are not to be construed as necessarily reflecting the views or possessing the endorsement of the Department of the Navy.

† Air Branch.

he needs in the way of information, but he can only compare one indication with another when asked what instrument he wants. The engineer, on the other hand, can only tell us whether or not it is possible and practical to make one indication or another. This is not meant to belittle either of these men but rather to point out the specific part of the program in which each should participate. The only practical way to get proper results from the people responsible for aircraft design is to have them work as a team, each covering his particular field of endeavor (Fig. 3).

Such a team requires a pilot to establish information requirements, a human engineer to take these requirements as a guide to establish display requirements, an engineering physicist to establish technical requirements for the display, and a group of engineers (mechanical, aeronautical, electronics, etc.) actually to design and develop the equipment.

Of particular importance to this team is the necessity for a guide. Such a guide would be in the form of a set of information requirements covering each phase of flight and would establish where we are and where we should go. By using such a set of requirements, it is rather easy to point out the weaknesses and inadequacies of our present instrumentation, as well as to establish the research and development required to take care of these deficiencies (Fig. 4).

For example, let us look at the first phase of any flight, the take-off. Let us assume that this is an instrument flight, in order to determine exactly what information must be provided in lieu of visual conditions.

We will discuss only two of the requirements in this phase of flight. The first bit of information required is the alignment with the runway. Here the pilot is concerned with his position with respect to the centerline—not heading as given by a directional gyro or compass. Heading alone will not tell him where the edge of the runway is as he starts his take-off run. In contact weather this information is apparent and easy to use, so in some way we must find a method of reproducing an analog of this data for instrument flight conditions. Thus we now have our first basic requirement—lateral position on the runway. No pilot can truthfully state that this is not necessary information. It is true that we make instrument take-offs without it, but it requires a great deal of concentration and continued practice.

The second requirement is position with respect to the length of the runway. In other words, the question asked by the pilot is, "Can we get air borne before we get too far down the runway?" This becomes extremely critical when operating from fields with short runways in aircraft with high load and low lift characteristics. This requirement may not be a necessity at all times, but it would relieve the tension of the pilot, and it is still a basic piece of information.

Going back to the reason for having orientation instruments you will recall that these are necessary because our vision is obscured at times, causing us to lose contact with the outside world. Is it not logical then to attempt to erase the medium that obscured our

PRESENT INSTRUMENTATION

Orientation	Operation
Gyro Horizon	Manifold Pressure
Directional Gyro	Tachometer
Rate of Climb	Oil Temperature
Turn and Bank	Oil Pressure
Radio Compass	Fuel Pressure
Magnetic Compass	Cyl. Head Temp.
Omni	Fuel Quantity
	Voltameter
	Clock

(Airspeed)
(Altimeter)

FIG. 1.

TYPES OF INSTRUMENTS

Orientation - What am I doing?

Director - What should I be doing?

Quantitative - How am I doing?

FIG. 2.

INSTRUMENT TEAM

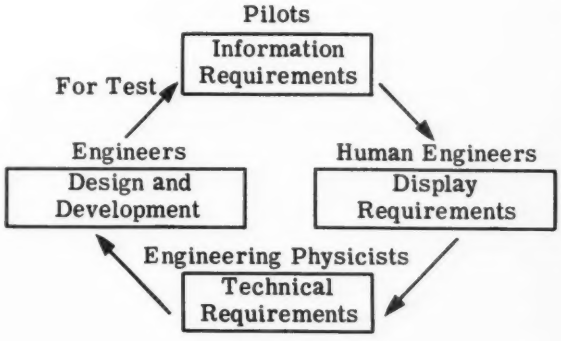


FIG. 3.

INFORMATION REQUIREMENTS

Takeoff			
Requirements	Existing	Development	Required R & D
Lateral Position	Directional Gyro	Directional Horizon	Runway Position
Longitudinal Position	———	———	Runway Position

FIG. 4.

vision or, in lieu of that, to develop an analog of what we have been seeing? From the day we first looked at the world, we became aware of certain characteristics of this visual world from which we are able to orient our body, as well as the machines we operate. Man was not designed to operate efficiently without full use of all his senses. The strongest of our sensory systems is vision. In maintaining balance in orientation it is the visual sense that supplements and refines the inadequate proprioceptive and equilibrium senses. For example, when making an ordinary turn in an aircraft under visual conditions, there is no apparent feeling of instability, nor does such a feeling occur when the turn is stopped and the plane is rolled out to level flight; yet under instrument conditions this same maneuver sometimes produces vertigo. The physiologists tell us that this is due to inertia within our vestibular apparatus which upsets our balance and produces this vertigo. It can be deduced from this that the information we receive from the artificial horizon and directional gyro is not strong enough to overcome this feeling of unbalance (Figs. 5, 6, and 7). It can be concluded, therefore, that, if the artificial horizon were designed to reproduce the visual cues that are apparent under visual conditions, vertigo could be eliminated.

From the previous discussion it is apparent that the manner in which data are displayed to the pilot *must be compatible* with the proprioceptive and the equilibrium senses in order to minimize the likelihood of disorientation. This requirement of compatibility immediately sets a limit on the number of possible ways of displaying the data.

Since we live in a visual world, it seems reasonable to believe that the visual cues we normally receive are the ones that are the most compatible with our other sensory inputs. Making this assumption, the next logical step in display design is to determine what specific visual cues we use for a given task (Fig. 8).

In this particular instance of take-off, where we are concerned with lateral position, we must consider *what it is in the visual world which permits us to maintain our position when our vision is not obscured.*

Normally we are aware of such things as the ends and sides of the runway, the horizon, peripheral objects, objects at the end of the runway, the runway centerline, etc.

By studying these objects that are apparent, we find that they have certain characteristics common to all of them. These characteristics we will call visual cues, and they comprise such things as size and shape, perspective, shading and color, positional cues, and motion. By carefully studying these visual cues we can determine which are most important in reproducing the desired analog of the visual world.

James J. Gibson, in his book *The Perception of the Visual World*, makes the following statement: "The stimulus variable within the retinal image to which a property of visual space corresponds need be only a correlate of that property, not a copy of it." In other words, if size and shape of the object are sufficient to provide the proper stimulus and produce the desired performance, our display requires no further elaboration.

If this display does not produce the desired effect, we must then continue to apply further stimulus properties until the presentation is adequate.

In addition to size and shape we can add texture, contour, adjacent location, and others (Fig. 9). By applying these various qualities to our display, we can develop an analog that more closely resembles the natural presentation.

The final proof of any new idea is in the testing, and, in order to test any analog of contact flight, we must first determine the level of performance we are trying to achieve. If we use as a yardstick the level of performance maintained under purely visual conditions, then at least we have a measurable base line. It may be true that there are better ways to fly an airplane than by visual or contact information, but before we look for these we should establish a system of instruments equivalent to the method by which we fly best today. At any rate, in this approach to instrument display design we make the assumption that, *if we can fly as well under instrument conditions as we do under visual conditions*, we will have come a long way toward better flight performance.

This level of performance can be established both analytically and by actual measurement. The analytical approach gives us a head start and is validated as the measurements become available.

As an example of what constitutes a level of performance, let us go back to the first information requirement—lateral runway position. Analytically, the minimum deviation from the centerline would be zero, and the maximum, of course, would be half the width of the average runway. By photographing many take-offs from the end of the runway, an average deviation could be established. It then follows that our task is to develop means of data display which will enable the pilot to perform within these limits.

In order to carry the display design to a successful conclusion through the development of actual instruments the following program is suggested.

The overall work should be divided into the three major areas of human engineering, feasibility studies, and systems studies, with all participants working as a team under one coordinator. The human engineering team should carry out the methodology described above and develop displays based on the information requirements. Working jointly with the human engineers, the instrument engineers should determine the technical requirements for each display. These technical requirements would then be turned over to the systems engineers who would adapt the various equations to universal computers and integrate the sensing requirements into a central sensing system, the display requirements into central display systems, etc. (Fig. 10).

These systems could then be integrated into the air frame proper by the coordinator to ensure the most efficient, reliable, and lightweight aircraft instrument system.

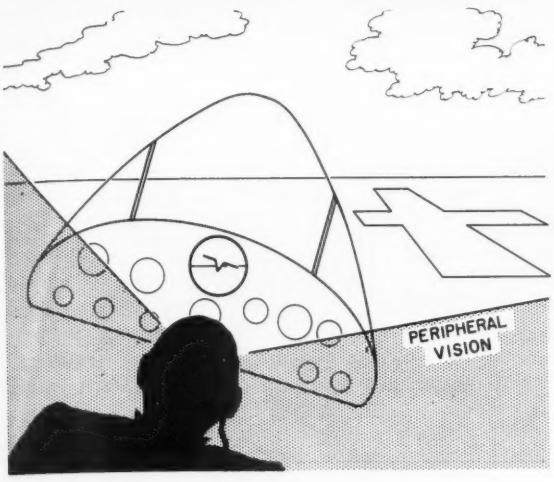


FIG. 5.

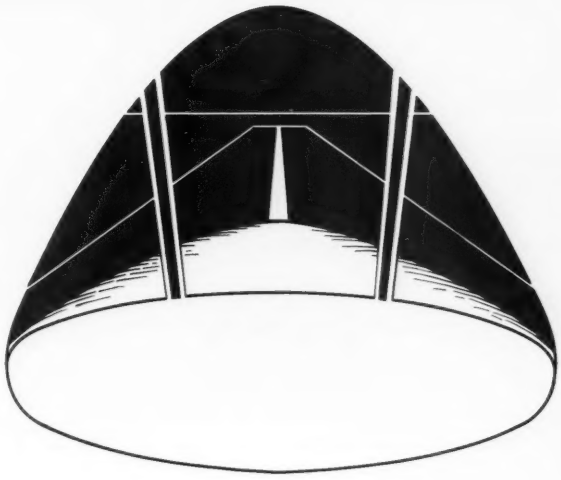


FIG. 8.

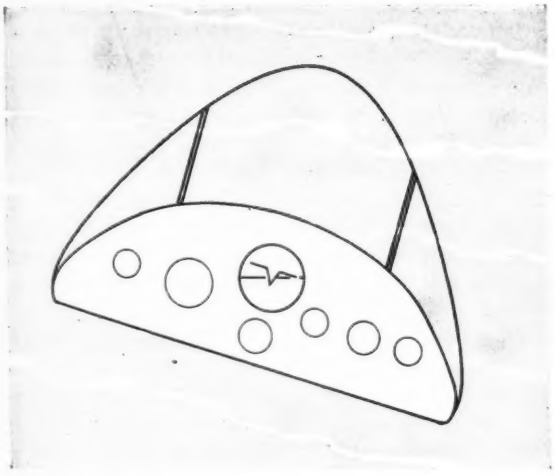


FIG. 6.

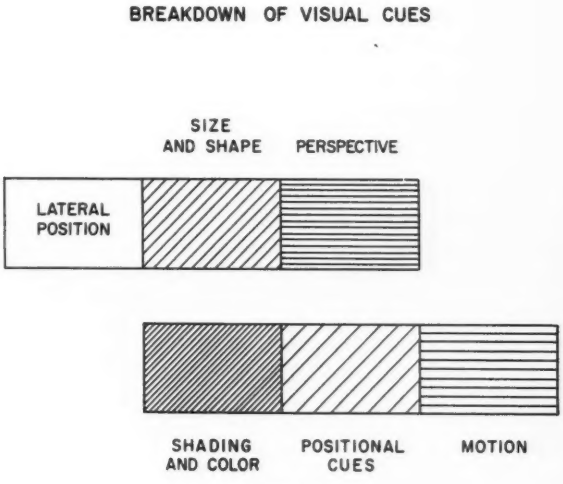


FIG. 9.

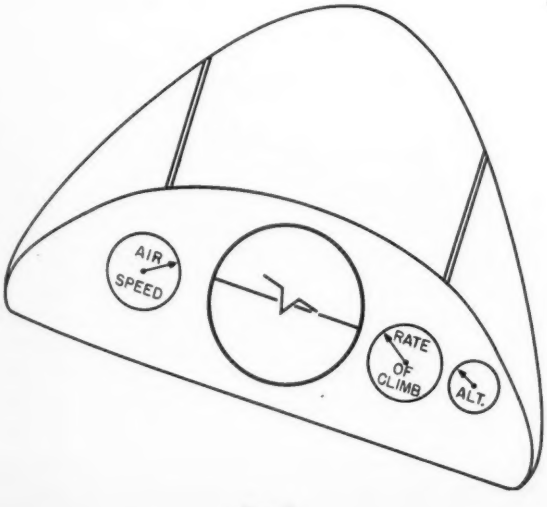


FIG. 7.

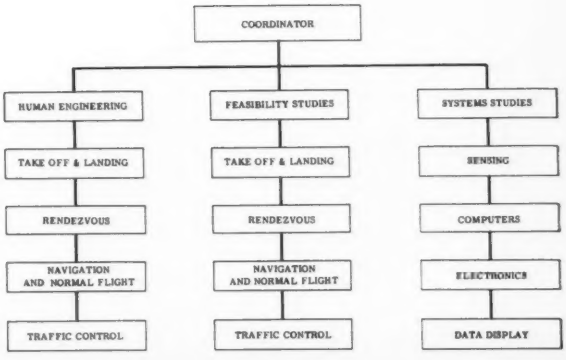


FIG. 10.

SUMMARY

TAKEOFF			
REQUIREMENTS	VISUAL CUES		
	PERSPECTIVE	MOTION	POSITION CUES
LATERAL POSITION	√	√	√

FIG. 11.

There are several points that are unique in this type of program—namely:

(1) There would be a division of responsibility in order to place the proper people in their most productive areas. The pilot can state the information required, the human engineer can determine the most effective display, the instrument engineer can determine the best methods of measurement and implementation, the systems engineer can develop the most efficient integration, and the coordinator—utilizing these systems—can develop the most efficiently instumented airplane.

(2) There would be formed a closely coordinated team in industry designed to make fullest use of the combined talents available.

(3) Duplication of effort could be eliminated.

(4) The standardization of an approach to the overall problem of instrument flight could be established and would have as a by-product the standardization of components.

CONCLUSION

One of the original thoughts in this paper was to establish a methodology for display design for orientation instruments that provide data normally obtained from visual contact, without permitting the design decisions to be influenced by personal opinion. It is believed that this has been accomplished. Let us review our example.

First, the fact that we must take off if we wish to fly is obviously not just opinion. Second, if the aircraft requires a forward run to become air borne, it necessitates knowing lateral position on the runway; a fact, not opinion. Third, by analyzing the visual cues that make our take-off in clear weather so easy, we can determine which of these cues are essential. Here, again, these cues are a part of the visual world, and certainly are no one's opinion. Fourth, the human eye and brain require certain perceptual stimuli in order to perceive an object in space. This is a fact of physiology and psychology, not opinion.

If this methodology is followed, regardless of who the designer is, the instrument display will always be fundamentally correct because it will have met not only the operational requirements but the psycho-physiological requirements as well. When all these requirements are met, our data display will be adequate, and the problem of "flying on instruments" will be eliminated (Fig. 11).

The Chinese were so right: One picture is still better than a thousand words—or symbols.

IAS Twenty-Fourth Annual Meeting

Hotel Sheraton-Astor, New York City, January 23–27, 1956

The Meetings Committee plans to schedule sessions on Aerodynamics, Aeroelasticity, Design, Electronics, Flight Propulsion, Instruments, Rotating Wing Aircraft, Safety in Flight, Structures, etc.

Members or organizations wishing to have papers considered for presentation at this meeting should submit outlines or short abstracts to the Meetings Committee, 2 East 64th St., New York 21, N.Y., no later than September 1, 1955.

O. E. BUXTON*
Jack & Heintz, Inc.

The Development of Oil-Cooled Generators

Description of design, installation, performance, and advantages of a new type of cooling for jet-engine accessories.

(I) Need for Oil-Cooled Generators and Early Development

Air-Cooled Generators Nearing Service Limits

For many years, air has been the acceptable standard medium for cooling aircraft generators and other rotating electric accessories.

Air cooling is simple. Actually, all that is involved in this technique is the taking of air entering a plane's "scoop" and ducting it through the accessory to be cooled. A basic air-cooled installation is shown in Fig. 1.

Many present aircraft will continue to employ air cooling, and further development will attempt to extend air-cooling service limits. Today, air-cooled generators are being redesigned with high-temperature components, new insulations, special "free flow" air passages, and other innovations. Recently, Jack & Heintz announced its G282 a.c. generator (Fig. 2)—one of the first air-cooled generators capable of operating at inlet-air temperatures as high as 120°C. (248°F.).

But, with supersonic flight speeds and continuous flight altitudes in excess of 40,000 ft., advanced high-performance aircraft can no longer rely on air-cooling systems. There are two major reasons:

Higher Altitudes—At the higher altitudes, air rarefies. As a result, the weight of cooling air that can be handled by normal ducting is considerably reduced. (See Fig. 3.)

Higher Speeds—The higher the aircraft speeds, the higher the ram-air temperatures rise, and the less effective becomes the air as a heat sink. (See Fig. 4.)

These factors, of themselves, do not preclude the use of air, but the associated design changes necessary to increase an air-cooling system's effectiveness do.

What is the practical limit of air-cooled machines? Studies indicate that the 120°C. machine is about the limit. In other words, air-cooled machines should be ruled out when an aircraft is expected to encounter inlet-air temperatures in excess of those quoted in the latest military Class C requirements—viz., 120°C. at sea level, 40°C. at 50,000 ft., and −12°C. at 65,000 ft.

Air-cooled machines might be developed to serve beyond these limits, but the feeling, generally, is that the air-cooled machines have presently reached the "end of the art." Effort expended to carry the machines further would require considerable time and would involve discovery of new alloys, insulations, etc. In view of the new liquid-cooled machines, such development effort appears impractical.

Oil-Cooling Developments Started in 1949

With the rapid pace of jet development, our engineers anticipated and reported the approaching limits of air cooling as early as 1949. In that year, they ini-

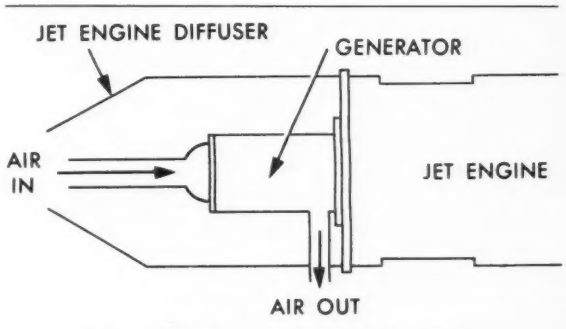


Fig. 1. Basic air-cooled generator installation.

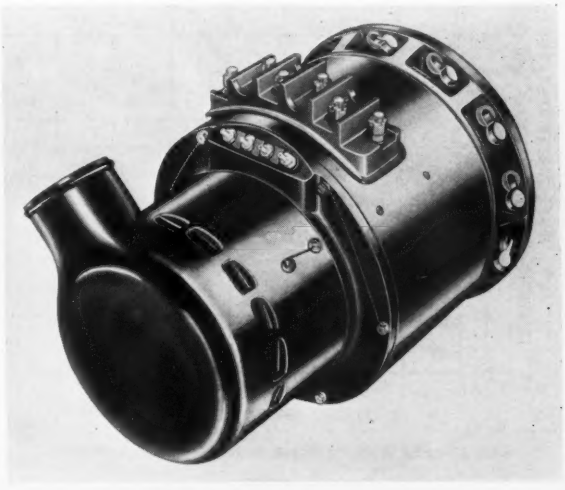


Fig. 2. G282 a.c. generator.

* Project Engineer, Oil-Cooled A-C Generators.

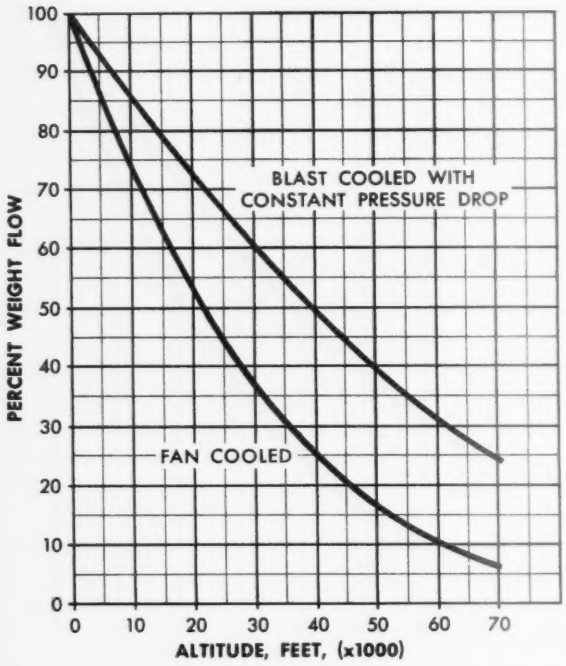


FIG. 3. Altitude influence on weight of air available in blast-cooled installations.

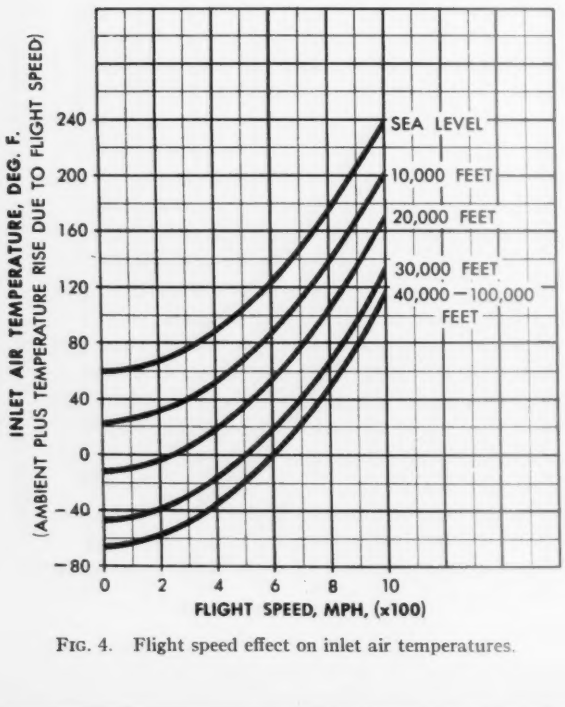


FIG. 4. Flight speed effect on inlet air temperatures.

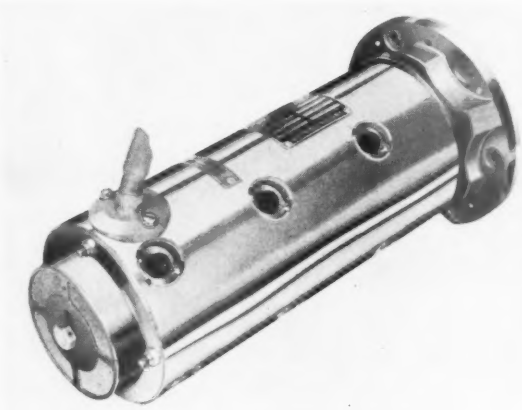


FIG. 5. G51-1 oil-cooled generator.

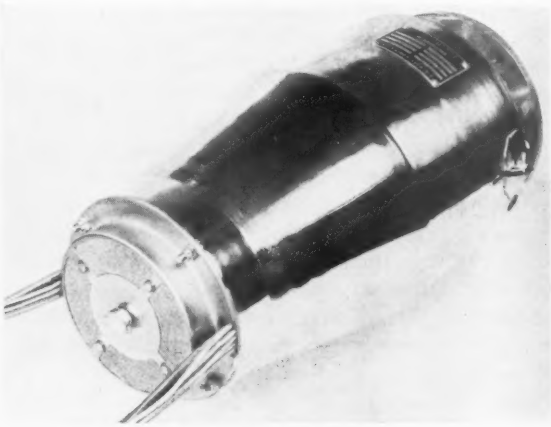


FIG. 6. G52 oil-cooled generator.

FIG. 7. G129 oil-cooled generator.

TABLE 1
Engineering Data on New Oil-Cooled Generators

Nominal Rating	2,500 Watts	9,500 Watts	100 Amp.	40 Kva.	20 Kva.	15 Kva.
Specification, reference	...	...	...	MIL-G-6099	MIL-G-6099	...
Drawing	G51-2	G52	G129	G190	G192	G280
Volts	**	**	28	120/208	120/208	120/208
Speed	12,000	12,000	8,000	6,000	8,000	12,000
Phase	**	**	d.c.	3	3	3
Frequency, c.p.s.	**	**	**	400	400	400
Power factor	**	**	**	0.75	0.75	0.75
Weight, lbs.	30	70	36	165*	100*	50
Moment, lb. in.	165	400	156	2,250*	1,100*	225
Length, in.	13.0	15.0	10.84	27.25*	26.0*	13.25
Diameter, in.	4.5	7.75	6.5	13.0*	9.0*	7.19
Mounting	**	**	**	AND20006	**	**

* Includes constant-speed drive.
** Special characteristics to meet customer requirements.

tiated the development of a liquid-cooled 30-volt 300-amp. d.c. generator weighing 66 lbs. Not too much was heard of this unit for the simple reason that it was ahead of its time—i.e., aircraft were not yet encountering flight conditions that could not be met by air-cooled machines. But it did alert the industry to the feasibility and exceptional potential of oil-cooled units and justified support for further development work.

For the past 6 years, we have concerned ourselves chiefly with the special problems associated with oil cooling—installation, sealing, bearings, and coolants.

As of today, we have entered pilot production on several oil-cooled units. That these units are the immediate successors to air-cooled units is borne out by the fact that major air-frame manufacturers, the Armed Services, engine manufacturers, and vendors are meeting to establish standards for oil-cooled units.

Noteworthy at this point is the fact that during their 6 years' work on liquid-cooled machines, our engineers evolved a vapor-cooled generator. Many believe that this machine may prove to be the ultimate configuration for aircraft generators and other rotating electric machinery for extreme high-performance supersonic missiles and aircraft. Some details on vapor-cooled units and remarks concerning their present status in aviation are included in Section III of this report.

(II) ENGINEERING DATA

As previously mentioned, we are in pilot production on several different oil-cooled generators. Figs. 5, 6, 7, and 8 show representative units. The new generators are varied. They range from the small multioutput a.c. and d.c. generators supplying power for electronic gear to the substantially larger a.c. and d.c. generators for an aircraft's main power supply. The small generators are rated in terms of watts; the largest a.c. generator is rated 40 kva., and the largest d.c. generator is rated 100 amp. The reportable engineering particulars on the new oil-cooled generators are compiled in Table 1.

The internal cooling system of one of these new generators is shown, in schematic, in Fig. 9. Oil enters the machine at the mounting pad, is circulated through the stator and rotor, and then returns to the engine at the mounting pad. A major difference in the mounting of this type of machine, over a blast-cooled machine, is that it can use only one bearing (at the antidrive end), with the drive-end bearing being supplied by the drive. The liquid used will most commonly be the engine oil or hydraulic oil, with the heat picked up in the generator being carried to whatever sink is ordinarily used for the liquid.

Perhaps the best way to point up some of the other unique design features of oil-cooled—as compared with air-cooled—units is to discuss the advantages that these

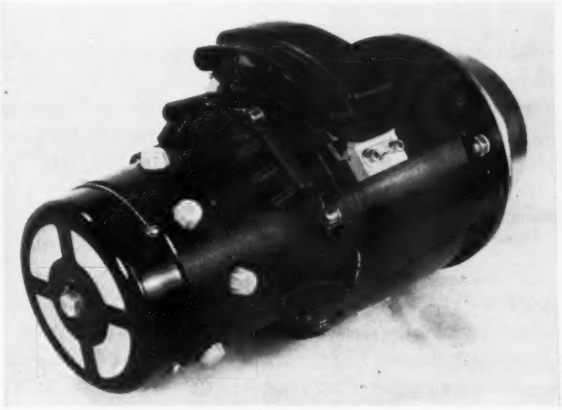


FIG. 8. G280 oil-cooled generator.

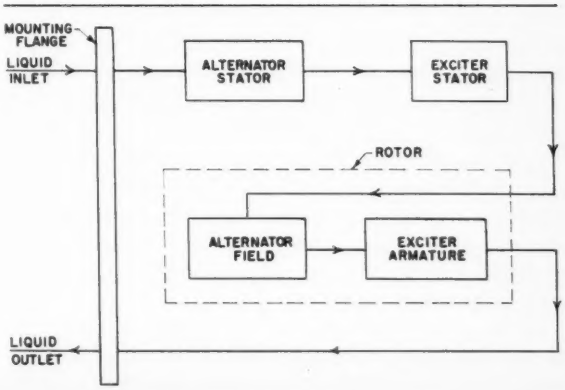


FIG. 9. Schematic diagram of oil flow through oil-cooled generators.

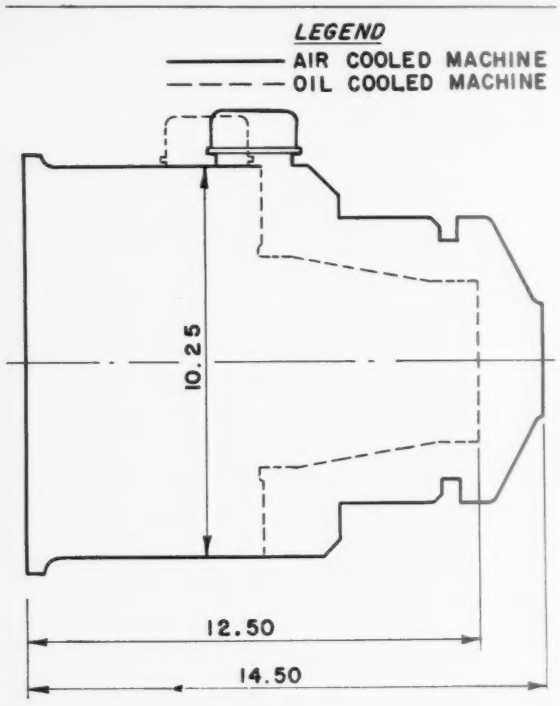


FIG. 10. Air-cooled vs. oil-cooled generators, typical size reduction.

machines offer to an aircraft, both in the sense of electric system and overall aircraft design.

To assist in placing the advantages in their proper category regarding the overall aircraft, they have been grouped under a few principal headings.

Space- and Weight-Savings and Less Congested Installation

An oil-cooled machine will be smaller in diameter and possibly shorter in length than comparable air-cooled machines because large airflow passages are eliminated in favor of smaller tubing. Today, the savings is of this order: 1/2-in. oil tubing replaces 3- to 4-in. air ducting and still larger shrouds. Fig. 10 gives a better idea of the size reduction. This figure shows the outlines of two 40-kva. generators—one oil-cooled, the other air-cooled.

Fundamentally, the cause of the size reduction and the tendency toward a slimmer configuration are thermal: An air-cooled machine has high temperature gradients in both axial and radial directions. Air does not travel too far through a generator—unless in great quantity—before it loses its effectiveness as a coolant. Therefore, provision must be made to have as much air as possible hit the face of the generator. This accounts for the increasing diameters of air-cooled machines to meet new service conditions.

In oil-cooled machines, the temperature gradients in an axial direction are substantially lower. These gradients are dependent on the liquid's heat-transfer coefficient, velocity, and weight rate. Under these conditions, it is possible to effect cooling by running oil tubing through the generator parallel to the axis. And so, oil-cooled machines will be smaller in diameter than air-cooled machines.

It should be noted that air-cooled machines (of the 120°C. class) use a fan and special water separator to increase cooling. These devices are not required on oil-cooled machines, thus enhancing overall size reduction.

The ultimate degree to which the diameters of oil-cooled units will be reduced will be dictated by the diameter-to-length ratio compatible with good electrical design. Both air- and oil-cooled machines are virtually the same electrically.

Both the size reduction and duct elimination aid substantially in relieving the present congestion on an engine pad and make room for other components.

In discussing space- and weight-savings, it must be remembered that certain increases in an aircraft's heat exchanger size may be necessary to accommodate oil-cooled accessories. Even with these increases, however, an overall space-savings is possible and a weight reduction is probable in all applications.

Reduced Drag and Increased Engine Thrust

Loss of ram air energy—as air passes through ducting and an accessory's internal passages—results in drag. This drag is entirely eliminated or considerably reduced with oil-cooled accessories.

At high speeds and relatively low altitudes, fuel consumption is high. Under these conditions, complete cooling of the engine and generator may be accomplished through fuel-to-oil heat exchangers. This means elimination of drag-producing air ducts.

At high altitudes, fuel consumption may be lower, and supplemental air-to-oil heat exchangers may be necessary to provide complete cooling. However, even at this condition, the air requirements will be low by virture of the high cooling efficiencies possible with air-to-oil heat exchangers. Hence, drag produced will be less than with comparable air-cooled units.

Actually, for aircraft subject to both conditions, it is possible to incorporate a recirculating system that can be switched from one heat sink to another, as demanded by the range of environments or operating conditions.

In some case, where oil-cooled equipment is used, bleed air ducts from the engine are eliminated entirely. This, in turn, improves engine air-flow characteristics, resulting in greater engine thrust and better engine performance.

Full-Rated Generator Output at High Altitudes

The decreasing effectiveness of air as a coolant at high altitudes necessitates derating air-cooled generators at those altitudes. The rating of a liquid-cooled machine, on the other hand, is independent of flight speeds and ambient and altitude conditions, so long as proper oil flow rates and oil inlet temperatures are maintained at the generator. In the case of the oil-cooled G190, for example, the generator will deliver full 40 kva. at a 0.75

power factor as long as oil at a 300°F. maximum is available in quantities of 5 gal. per min.

Elimination of Generator Hot Spots

Some background is necessary here. The higher the temperature level a machine is able to withstand by itself, the smaller (in size and weight) the cooling system required, irrespective of cooling medium. For this reason, generators are pushed to as high an operating level as possible, until one of the components reaches its critical limit. In the perfect machine, of course, all components reach their critical limit at the same temperature.

The design problem, consequently, shifts from one component to another, until each is improved or until better cooling methods are devised to put the critical limit where desired.

The logical step toward arriving at a perfect machine is to eliminate the temperature gradients and hot spots.

Even with careful design, it is practically impossible to eliminate hot spots in blast-cooled machines. The primary reasons are the high axial temperature gradients, discussed under the heading Space and Weight-Savings. It should also be remembered that these gradients may change depending on load and axial airflow.

In liquid-cooled machines, on the other hand, gradients occur in the radial direction, and they are dependent mostly on the load since the flow rate of the coolant is constant regardless of altitude. Further, the temperature rise of the liquid will be small enough so that, regardless of how the liquid is circulated, the last component to be cooled will have cooling-liquid at nearly the same temperature as the first component to be cooled.

Therefore, in liquid-cooled machines, hot spots can be greatly reduced and thermal gradients can be kept within safe limits. This, in turn, tends to minimize the following problems associated with air-cooled designs at high speeds and altitudes: bearing failure, insulation failure, strength deterioration of metals, loose fits, and high internal stresses. Gains in these areas mean longer generator life and reliability.

Perhaps the most serious component problem eased by the reduction of hot spots is that of bearings. The oil-cooled method makes it possible for the designer to eliminate gradients across the bearings—if two bearings are to be used. However, on liquid-cooled machines, the trend is toward only one bearing—viz., the antidrive bearing. This greatly simplifies the control of bearing operating conditions. Also, with oil-cooling, it is probable that grease-lubricated bearings, presently used, will be replaced by the more efficient oil-lubricated bearings. On a blast-cooled machine, this would involve considerable redesign, not only of the generator itself but also of the engine or the accessory section, depending on where the lubricating oil originates. In a liquid-cooled machine, particularly if engine oil is being used as the coolant, the modification for the one bearing is relatively simple because oil is already circulating through the machine.

Stable Generator Design

As mentioned before, the electrical design of an air-cooled generator is virtually the same as that of an oil-cooled unit. But, from this point on, there is a significant difference. While air-cooled generators are in a constant state of design flux, requiring redesign for each major advance in aircraft, the oil-cooled generators need not be changed to meet new conditions.

Restated simply, in the case of air cooling, air was losing its effectiveness and the generator design had to be improved to compensate. With oil cooling, the cooling system is not only far more efficient but also more flexible, and the generator design becomes important only in the light of electrical requirements.

An oil-cooled generator can, for example, serve as wide a range of environments as the efficiency of the heat exchanger and rate of oil flow will permit.

There may be changes in generator design as new techniques of power conversion are proved. But it is, even now, quite possible for the aviation industry to arrive at a standard generator for each of the required ratings and to govern the service limits of these machines by modifications to the heat exchangers. Because there are many possible variations of a heat exchanger—for example, fuel-cooled, cabin cooler, and evaporative—the future of oil-cooled units appears exceptional.

(III) The Future of Aircraft Generators

At the outset it should be stated that oil-cooled machines are established as the next step toward "environment-free" accessories for aircraft. The machines being produced now at Jack & Heintz are not designed to fulfill the entire range of present and future aircraft needs. Each unit designed will offer a particular solution to an installation or an environmental problem.

We believe oil-cooling to be the most practical approach to the problem of removing heat from generators in present and many future high-performance aircraft. This method permits electric accessories to use the same working fluids as modern turbine engines, gear boxes, hydraulic systems, and constant-speed drives. So long as the gear box or engine utilizes a lubricant compatible with good heat transfer characteristics, a single cooling circuit employing already available pumps, sumps, and external plumbing is possible. If desirable, a completely separate oil-cooling system can be utilized, or a generator cooling system can have components in common with another cooling system.

It is important to remember, too, that while oil-cooling does fill existing and anticipated requirements, it brings with it certain problems that must be solved such as high-performance coolants and positive static and rotating seals. These problems have been largely overcome at our laboratory through considerable development and testing.

In the light of present knowledge, the following summary may be drawn:

(1) For low-altitude, low-speed flight the blast-cooled machines will still do a fine job.

FIG. 11. G75 vapor-cooled generator.

(2) For high altitudes and high speeds of sufficiently short duration, blast-cooled machines may still be used, but flight and load cycles must be checked against evaluation charts to pick the proper machine. Of course, under these conditions, it is time to start thinking of oil-cooled machines. In fact, whenever an aircraft's inlet-air temperatures are expected to exceed 120° C. (sea level), liquid-cooled machines should be planned.

(3) For a wide range of supersonic speeds at high altitudes, oil-cooled machines will do the job. Here, the capacity of the heat sink must be determined to establish the liquid-temperature level that can be maintained. This, along with a knowledge of the liquid to be used, will determine the precise service limit of the liquid-cooled machine.

(4) For the extreme high-flight speeds and altitudes being encountered by missiles, thermal lag or vapor-cooled machines may be required. The present thermal lag machines are suitable for only short-time applications. Bearing the greatest promise for extreme service and long operating periods are the vapor-cooled units already being used extensively on missiles.

We have two such machines in pilot production—the G75 (Fig. 11) and the G188, operating at 12,000 r.p.m. and rated 12 and 30 kva., respectively. Basically, a vapor-cooled machine operates as follows: Coolant (water from a reservoir) is injected, under pressure, into the generator's hollow shaft. Centrifugal force propels the water in spray form through four ports, scattering it on the internal surfaces of the machine. As it picks up heat from these surfaces, the water vaporizes, and the resultant steam escapes through an exhaust port.

These vapor-cooled machines are as nearly "environment-free" as any yet developed. They appear to be practical for aircraft as soon as the question of coolant requirements is resolved. The G188 uses approximately 9 lbs. of water per hour at full load.

Special IAS Publications

	Member Price	Nonmember Price
Aeronautical Engineering Index – 1953	$ 3.00	$ 5.00*
1952	2.50	4.00*
1951, 1950, 1949, 1948, 1947 (each)	2.00	3.00*
Proceedings of the Turbine-Powered Air Transportation Meeting	3.50	6.00*
1955 National Telemetering Conference Record	3.50	3.50*
1953 and 1954 National Telemetering Conference Record (each)	2.00	2.00*
Second International Aeronautical Conference Proceedings	15.00	17.50*
First Convertible Aircraft Congress Proceedings	3.00	5.00*
Second Convertible Aircraft Congress Proceedings	3.00	5.00*
Eighteenth Wright Brothers Lecture—Fatigue Life of Airplane Structures, Bo Lundberg (Reprinted from the June, 1955, JOURNAL OF THE AERONAUTICAL SCIENCES)	1.00	1.50
Seventeenth Wright Brothers Lecture—The First Half-Century of Flight in America, Glenn L. Martin (Reprinted from the February, 1954, JOURNAL OF THE AERONAUTICAL SCIENCES)	0.50	1.00
Sixteenth Wright Brothers Lecture—Technical Trends in Air Transport, William Littlewood (Reprinted from the April, 1953, JOURNAL OF THE AERONAUTICAL SCIENCES)	1.00	1.50
Index to Books on Selected Technical Subjects in the IAS Library (up to 1950), unbound	2.00	2.00*
"Fifty Years of Flight"—A Chronicle of the Aviation Industry in America, 1903–1953, Welman A. Shrader (Published by Eaton Manufacturing Company. Reprinting and Distribution Rights Granted to IAS)	4.50	5.00

*Add $1.00 for orders outside the U.S.A.

These may be obtained by writing to:

Publications Department, Institute of the Aeronautical Sciences, Inc., 2 E. 64th St., New York 21, N.Y.

A proposal that designs of all future air frames provide for possible rocket installations and that rocket subassemblies may thereby become standardized.

Superperformance Rockets for Fighter Aircraft

ROBERT GORDON*
Aerojet-General Corporation

Introduction

There are available several thrust augmentation or "flash-performance" devices that markedly increase the performance of aircraft for short periods of time—i.e., 1 to 5 min. These are not new in concept or application. The Germans in 1944 planned to feed bottled nitrous oxide to their reciprocating engine, the BMW-801E, to obtain increased power at altitude.[1] The afterburner,[2] water-alcohol injection,[3] solid powder rockets,[4] and liquid propellant rockets[4,5] have all been used to provide augmented thrust. Boundary-layer control,[6,7] which may be used when extra lift is required, is a superperformance method that is not based on added thrust. This technique is not included in the following discussion.

Extra weight, cost, complexity, and logistic problems usually attend the usage of a superperformance device. The most serious drawback is probably the loss in airplane performance during the time the superperformance device is carried along without being used. The fact that many of these devices are in use or being developed indicates that, under certain conditions, the added thrust is worth the installation penalties. It is usually found that the unit having the highest additional thrust also has the poorest specific fuel consumption—i.e., the rocket—while the simplest and most desirable unit, from the air-frame manufacturer's viewpoint, usually has a limited ability to produce extra thrust—i.e., water-alcohol injection. There is, then, no natural best type of unit, and the selection among the various superperformance devices usually requires an engineering study in which the weight, specific fuel consumption, and complexity (reliability) of each device is compared to the amount and duration of the extra thrust obtainable.

It is believed worth while to review the tactical situations requiring extra thrust and to establish estimates of the amount of extra thrust required and its duration.

Assisted Take-Off

Optimum utilization of the turbojet engine thrust in the flight of subsonic jet-powered airplanes requires approximately 50 per cent extra thrust at take-off if reasonable runway lengths are to be maintained. A duration of less than 60 sec. is usually adequate for take-off and "cleanup" of the airplane from conventional runways.

Climb to Altitude

To the best knowledge of the author, there are no commonly accepted rule-of-thumb criteria for optimum extra thrust in this situation. Some studies have recommended as little as 20 per cent extra thrust—i.e., between 1,000 and 2,000 lbs. This requirement obviously is extremely dependent on values of scramble time which, in turn, are based on assumed effectiveness of warning radar and airplane climb performance.

In-Flight Thrust Augmentation at Altitudes

All requirements for extra thrust at high altitude stem from the loss in thrust of air-breathing engines as ambient density is decreased. The "flash-performance" device should therefore not suffer from this failing. The quantity of thrust should be equivalent to approximately 1/3 of the gross weight of the airplane—or approximately the sea-level thrust of the turbojet. The duration of this thrust should be controllable and sufficient for at least one combat engagement—or approximately 2 min.

Supersonic Acceleration

An impending new application of augmented thrust at altitude is to assist the supersonic airplane to accelerate in the supersonic range where the difference between the thrust and drag is small and fairly constant over a large Mach Number range.

A device that fits these requirements is the liquid-propellant rocket. Its thrust level is not dependent on, and may be several times that of, the basic turbojet. Its thrust increases with altitude, and it may be turned on and off as desired. However, this unit has the disadvantage of high fuel consumption as compared with the other thrust devices.

It is not the intent of this paper to claim for the liquid rocket general superiority to other thrust augmentation

* Project Engineer.

methods. For any specific application, the selection should be based on a thorough and objective engineering study. It is the intent of this paper to answer the questions, "Are thrust augmentation devices in general and liquid rockets in particular required at all? If so, where and when, and why do we not have them available now?"

In attempting to evaluate the pros and cons of a thrust augmentation application to any specific airplane, there is always the necessity of comparing dissimilar objects without a suitable evaluation technique. The propulsion people emphasize the higher rate of climb at altitude, the lesser time to climb to altitude, the increase in speed, the decrease of turning radius, and the other aspects on the favorable side; whereas the airframe people insist upon discussing the increase in gross weight, the decrease in combat radius, the increase of take-off distance, and the other unfavorable aspects of an installation.

One method of reconciling these different viewpoints is to separate airplane performance parameters into two groups: first, those associated with the few minutes of operation where the pilot is actually engaged in combat; second, those that describe the airplane's performance in servicing, take-off, climb, range, and endurance—those parameters describing the ability of the pilot to get into a position to initiate combat. It appears that the thrust augmentation device invariably enhances the first group of parameters at the expense of the second. It is believed that if the parameters of the first group for a given airplane are poorer than the comparable parameters of an enemy airplane, then a thrust augmentation device, such as a rocket or afterburner, is a necessity for the first airplane. If the use of a rocket results in decreased range, greater take-off weight, and longer take-off runs, then these penalties must be paid. It is usually simpler to accommodate the last-mentioned penalties because the means for so doing are relatively well known, whereas the means of obtaining inherently better performance in flight are not simple or readily available. It would, therefore, appear that thrust augmentation is a necessity only if the enemy plane has better performance during the actual combat engagement. A corollary of this conclusion appears to be that it is best for a given plane to have Group 1 parameters only slightly better than the enemy plane and to capitalize on any excess capacity for weight by extending the range and duration of flight so as to minimize logistic problems.

Every airplane at the time it is designed is the "hottest" airplane in the world, and the Group 1 performance parameters are always better than those the enemy has or is known to be considering. Therefore, there is no apparent necessity—and no attempt is made—to design the airplane to accommodate a thrust augmentation rocket. However, by the time this airplane is operational, it is usually found that a need does exist for improved performance because either the enemy aircraft has better performance than anticipated or our final airplane performance has been reduced by the extra equipment or pay-load requirements of tactical usage. When this situation appears, a frantic crash program is then initiated "to do something" to improve the performance of the airplane and to fill in the lead time required for the next advanced model. Such programs were initiated on the P-51 and F-80 airplanes and completed successfully but too late for operational use. Demands for a similar "fix" for the F-86 were heard during the Korean action when some of our pilots reported that the MIG could fly higher and faster and climb faster above 40,000 ft. than the F-86's.

It thus appears that in the history of a fighter airplane the requirement for assistance in achieving added performance is not apparent at the beginning and is strongly apparent at the end. It therefore seems desirable that the airplane design competitions sponsored by the Services should include as a requirement that the manufacturer show the method proposed to provide augmented performance and thus delay the obsolescence of the airplane 5 years hence. The Services should then develop rockets or other devices for adaptation to the specific airplane when needed. It is believed that these units should be Government-furnished because the Service will be the owner of the airplanes and the party most concerned with maintaining the operational suitability of aircraft that are rapidly becoming obsolete.

As a result of examining the installation problems of a superperformance rocket in many aircraft, it appears to this author that dissimilar airplanes will not take an identical rocket. Problems of c.g. disturbance, thrust line location relative to the c.g., ground clearances, radiation heating, available space in the air frame, and pod size and shapes make it extremely improbable that a standard rocket will be suitable for an internal airplane installation if the original design of the airplane does not make provision for its use. It is therefore considered that the direction of a rocket development program should be toward the developing and proving of standardized subassemblies such as the thrust-chamber assembly, pump-drive assembly, and individual auxiliary components. These could then be rapidly repackaged to fit any new installation. Any advanced and highly integrated rocket will be suitable for multiple use only if the requirement is immediately instituted that all future airplanes make provision for possible rocket installations.

To summarize these observations, it seems that

(1) A thrust augmenting device is a necessity, if—and only if—our airplane has poorer performance than the enemy plane while engaged in actual combat. Problems of logistics and operating range adversely affected by such an installation must then be overcome by other methods.

(2) Suitable devices for imparting superperformance to airplanes for short periods of time do exist and have been developed and used.

(3) The need for a rocket or other thrust augmenting device is always discounted during the early design

(*Continued on page 35*)

Variable-Stability Airplanes in Lateral-Stability Research

NACA applications of servoactuated control equipment for studying stability problems of piloted airplanes.

WILLIAM M. KAUFFMAN* and FRED J. DRINKWATER, III†
Ames Aeronautical Laboratory, NACA

Introduction

THE PHRASE "variable-stability airplanes" refers to piloted airplanes whose stability characteristics can be varied by servoactuation of control surfaces. Application of such equipment as a flight-research tool was initiated at the NACA Ames Aeronautical Laboratory in 1947 when the aileron system of a conventional propeller-driven F6F-3 airplane was modified to furnish large changes in dihedral effect. Early flight tests to evaluate this equipment and the effects on handling qualities of wide variations in effective dihedral were reported in 1948 and 1949.[1, 2, 3] Since then, similar servomechanisms have been installed in the rudder systems of this airplane and an F-86A airplane to provide large variations of the yawing-moment derivatives.

In the present paper, this Ames variable-stability equipment will be described briefly. Several general applications that have evolved over recent years will then be reported and—to the extent permitted by security—illustrated by means of specific examples.

Apparatus

There are several ways of incorporating variable-stability equipment in an airplane. The one used in the Ames variable-stability airplanes can be demonstrated by a simplified diagram of a typical rudder installation shown in Fig. 1. Here the pilot's rudder control system is conventional, except for a differential linkage inserted in the connections between the rudder pedals and the rudder itself. This differential permits simultaneous actuation of the rudder by the pilot and by a servo in the variable-stability system, so that the total rudder motion is the sum of the pedal-applied and servo-applied motions. The pilot thus retains control of the rudder, but the apparent directional stability characteristics of the airplane are altered by the yawing moments produced by the servo-applied rudder motions. For example, in order to change the apparent static directional stability derivative C_{n_β}, a signal proportional to airplane sideslip angle is generated by an electrical pickoff on a sideslip vane. This signal is then amplified and sent to the servo, which moves the rudder an amount proportional to sideslip angle, thereby altering the rate of change of yawing-moment coefficient with sideslip angle or, in other words, C_{n_β}. The sign and magnitude of the change in C_{n_β} can be readily adjusted in flight by means of a potentiometer that controls the ratio of servo-motion to sideslip angle.

Changes in the apparent yaw-damping derivative C_{n_r} or the cross derivative C_{n_p} are produced in much the same manner. A rate gyro senses the rolling or yawing velocity and sends a corresponding electrical signal through the summing amplifier to the servo. The servo deflects the rudder an amount proportional to the angular velocity, thus producing the desired change in the yawing-moment coefficient per unit angular velocity. The magnitude and direction of the change in C_{n_r} and C_{n_p} are also adjustable by the pilot, and the summing amplifier permits establishment of any desired combination of changes in the individual stability derivatives.

The rough-air generator is an additional feature that has proved extremely useful. A cam-driven potentiometer generates a signal of a random type which is amplified and sent to the servo. The resulting rudder motion causes yawing disturbances similar to those

TYPICAL AMES VARIABLE-STABILITY SYSTEM

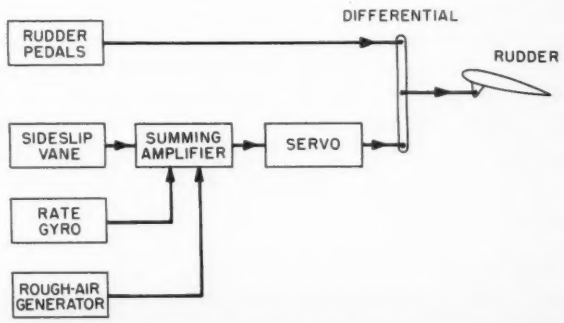


FIG. 1.

Presented at the Stability & Control Session, 23rd Annual Meeting, IAS, N.Y., Jan. 24–27, 1955.

* Aeronautical Research Scientist.
† Aeronautical Research Pilot.

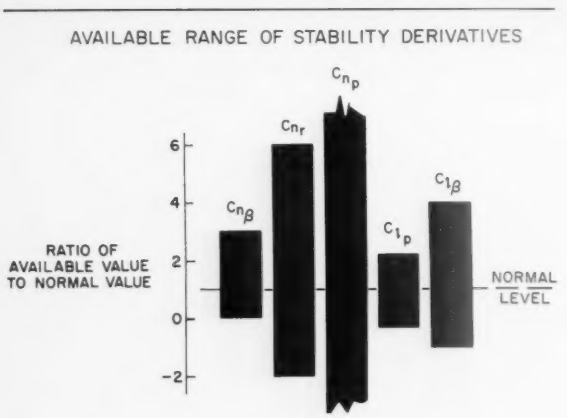


FIG. 2.

encountered in rough air. The pilot can switch this device on whenever he wishes and can also adjust the average frequency and amplitude of the disturbances. The hinge moment associated with this and all the other servo-applied rudder motions of course feed back to the pilot's rudder pedals. However, these moments are kept small by also driving the rudder tab with the servo to provide a balancing effect.

The preceding discussion applies not only to the rudder drive systems in the Ames F6F and F-86 airplanes but also to the aileron drive system in the F6F. In this case, an aileron servo is used to produce changes in rolling moment proportional to sideslip angle and to rolling velocity, thus giving changes in the effective-dihedral derivative C_{l_β} and the roll-damping derivative C_{l_p}.

The ranges over which lateral and directional stability characteristics can be varied with this equipment are indicated in Fig. 2. The bar graph illustrates the ranges of important stability derivatives as ratios of values available with the variable-stability equipment to the normal value for the test airplane. The normal values for these airplanes are conventional for the type and design eras. The data for the rolling-moment derivatives apply to the F6F, the only Ames airplane in which they can be varied, whereas the yawing-moment graphs represent the average ranges for the F6F and the F-86. The maximum values shown here are those used normally and are not necessarily the maximum obtainable. Flight safety considerations generally govern the maximum usable values, particularly through the use of stops on the servos which limit their authority and thus provide adequate control for the pilot. It is seen that the static directional-stability derivative C_{n_β} can be varied to cover a range from zero or neutral stability to several times the inherent positive stability. The yaw-damping parameter C_{n_r} can be adjusted from a sizable unstable value to one about six times greater than normal. The inherent values of the cross derivative C_{n_p} are small, and hence extremely large percentage changes are possible in either direction. On the F6F airplane, the roll-damping derivative C_{l_p} can be adjusted to between slightly negative damping and more than twice the sizable inherent value. The dihedral parameter C_{l_β} is variable over a range corresponding to effective dihedral angles from $-5°$ to $+25°$.

Through these large changes in the stability derivatives, the variable-stability airplanes also provide correspondingly large variations in Dutch-roll or lateral-oscillation characteristics. This is demonstrated in Fig. 3, in which available regions of oscillation period and damping are represented by the shaded areas. The dotted areas are the regions that can be covered by the normal F6F and F-86 airplanes, while the cross-hatched areas show the much wider regions obtainable with the variable-stability equipment. The boundary between satisfactory and unsatisfactory behavior formerly specified by the Air Force and the Navy is also shown for comparison. It is seen that the F6F equipment can be adjusted to give periods ranging from about 2 sec. to greater than 7 sec., while the damping can be varied from short times to double amplitude T_2 (that is, rapidly divergent oscillations), through neutrally stable oscillations, and on to extremely short times to damp to half amplitude $T_{1/2}$ (corresponding to nearly critical damping). The F-86 variable-stability airplane extends the available region down to periods as short as 1 sec., with similar capabilities for altering the damping. The region of short periods and poor damping has been of particular research interest because of the trend in that direction associated with modern airplane configurations and increased flight speeds and altitudes. On the other hand, the high-damping region is also of interest in connection with related applications of powerful yaw dampers.

It should be noted that the variable-stability airplanes have provided considerable early flight experience in such regions at the time they were just being encountered in operational aircraft design. This flight experience has been widely distributed among pilots from Ames and other Laboratories, the Air Force, the Navy, and aircraft companies—for example, over 40 pilots have flown the F6F airplane equipped with some form of variable-stability apparatus for a total of more than 400 hours.

APPLICATIONS

Study of Flying-Qualities Requirements

The ability to produce lateral and directional behavior characteristic of modern airplanes immediately suggests the use of these variable-stability airplanes in systematic flight studies to identify new problems and to aid in establishing related flying-qualities requirements. In fact, the first flight investigation utilizing variable-stability equipment was of this type, a study involving large changes in effective dihedral on the Ames F6F airplane. While this and subsequent flight experience has verified that variable-

stability airplanes are well suited for such work, it has proved difficult to establish quantitative lateral and directional stability requirements that are generally applicable, particularly when dynamic behavior is considered.

For example, the early F6F tests indicated that pilots rated the lateral oscillatory behavior as less satisfactory when the ratio of the amplitude of the rolling motion to yawing motion was increased.[2, 3] This trend was verified in subsequent, more extensive tests with the F6F in which the addition of the rudder drive system permitted larger independent variations of lateral-oscillation period, damping, and roll-to-yaw coupling. However, it is hard to define boundaries or other quantitative relationships between, say, a damping parameter and a roll-coupling parameter which separate satisfactory from unsatisfactory behavior.

Several of the apparent difficulties can be demonstrated by Fig. 4, which shows possible lateral-oscillation boundaries in terms of a damping parameter and a roll-coupling parameter. The first problem is to select the parameters of greatest importance to pilots, and the possibilities here are large. For example, the damping parameter might be the time or number of cycles to damp to half amplitude or the damping ratio. The roll coupling could be expressed in terms of the ratio of roll angle, velocity, or acceleration to yaw angle, velocity, or acceleration, or to sideslip angle. The oscillation period might be expected to influence pilots' opinions, and thus should appear either separately as a third parameter or implicitly in the other two. The fact that many airplanes now employ yaw dampers or other stability augmenters introduces another complication—the need to define not only a boundary separating a satisfactory and unsatisfactory behavior for normal flight but also a boundary that will ensure tolerable behavior under the emergency conditions associated with damper failure.

Another bothersome trend is illustrated in Fig. 4, in which boundaries based on recent pilots' opinions tend to be more lenient than those deduced from earlier studies. Trends of this type may be associated with the increasing familiarity of pilots with later operational aircraft that have such previously unfamiliar characteristics as poor damping and high roll coupling. However, there is an indication that this particular trend may reflect apparently minor differences in the techniques used in the various studies in briefing the test pilots and in interpreting their opinions. Among other problems are the usual variations in opinion from pilot to pilot, the heavy influence on pilots' opinions of the other characteristics of the test airplanes, and the need for quantitative flight data to check pilots' opinions.

It should be emphasized that the numerous difficulties just discussed do not arise from deficiencies in the variable-stability airplanes, but are common in the establishment of any flying-qualities requirement. In fact, these airplanes have successfully demonstrated one important advantage over any other method of obtaining such flying-qualities data—namely, the ability to evaluate the effects of changes in one or more selected variable-stability parameters during a single flight, so that the pilot, the airplane, and all other test conditions remain constant.

Simulation of Prototype Airplane Characteristics

Considerable attention has been devoted at Ames to another application of the variable-stability airplanes—that of simulating various predicted lateral and directional flight characteristics of prototype airplanes as an aid to the designers. The ranges of test conditions and stability characteristics are narrowed to regions of specific interest, and thus uncertainties involved in extrapolating the results of the broader research studies are avoided. The usual procedure here has first involved estimation of the mass, stability, and response characteristics of the prototype. Depending on the problem, either the F6F or F-86 variable-stability equipment is adjusted to give the best match to the predicted lateral and directional stability characteristics of greatest interest. In some cases, only lateral-oscillation period, damping, and roll-coupling are simulated, but often other predicted unusual stability or response features are provided by special modification of the equipment. Ordinarily no attempt is made to match the individual mass or stability parameters of the prototype but only to adjust ratios and combinations of the Ames airplane parameters to give similar dynamic stability and response characteristics. A test pilot and aerodynamicist from the company concerned then come to the Laboratory for a series of cooperatively planned simulation flights by the company pilot. Although these simulation programs are specific in nature, they often suggest trends and paths for further research, as will be indicated in the following examples.

In the first example, analog computer studies of a proposed airplane showed unusual rolling motions in response to abrupt deflection of the rudder in the landing-approach condition, and a flight study was considered advisable. The nature of this rolling behavior is shown in Fig. 5, which presents time histories of the bank angle and sideslip angle in response to an abrupt

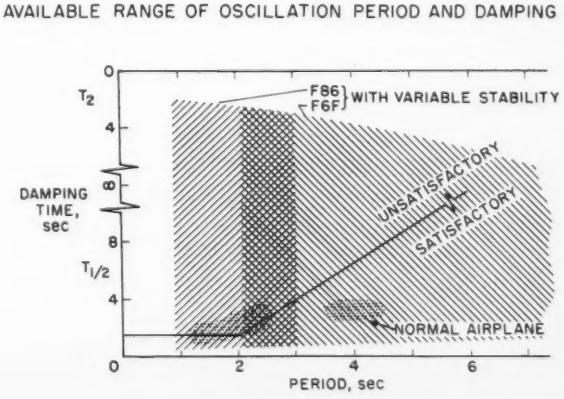


FIG. 3.

stick-fixed rudder kick. The bank-angle curves illustrate the effect of various amounts of $Cl_{\delta r}$, the rolling-moment coefficient due to rudder deflection itself, for a step-type left deflection of the rudder which produces an eventual right sideslip of about 5°.

The curve marked "negligible" typifies the usual case of positive dihedral effect and small rolling moments due to the rudder itself. As the airplane sideslips to the right, the leading or right wing tip rises and the left bank continues to increase. On the other hand, if the rudder center of pressure is located high, rudder deflection causes rolling moments that are large and adverse, in the sense that they oppose the rolling motion associated with positive dihedral effect. This results in an initial right bank following a left rudder kick. If the adverse $Cl_{\delta r}$ is sufficiently large, it will overpower the positive dihedral effect, and, as indicated in Fig. 5, the bank angle will continue to increase to the right, much as though the airplane had negative effective dihedral. The predicted behavior of the prototype airplane lay somewhere between these extremes and is represented qualitatively by the curve labeled "moderate adverse" $Cl_{\delta r}$. Here the initial bank is to the right, but the positive dihedral effect is sufficient to produce a normal left banking motion as the right sideslip builds up. Since a pilot often wishes to use the rudder in adjusting the flight path during landing approaches, the question of whether this predicted unusual rolling motion would be acceptable was one of practical importance.

The usual procedure was followed in attempting to answer this question, with the F6F variable-stability being adjusted to give the controls-fixed lateral-oscillation characteristics predicted for the contractor's airplane. In addition, an electrical pickoff actuated by rudder-pedal motion was installed, and the signals were fed to the aileron servo to produce a rolling moment proportional to pilot-applied rudder deflection. The gain of this circuit could be adjusted in flight to simulate a wide range of adverse $Cl_{\delta r}$ such as shown in Fig. 5; in fact, these time histories were taken from F6F flight records.

Subsequent F6F flights to evaluate this effect of $Cl_{\delta r}$ indicated that, with the value predicted for the new airplane, the initial adverse roll was noticeable to the pilot but not sufficiently large nor persistent to interfere seriously with control of the airplane. It is understood that this opinion was verified later in the first flights of the prototype.

In the second example, wind-tunnel tests of a new model indicated that the static directional stability C_{n_β} would be reduced to extremely small values in the event of stability-augmenter failure at a critical flight condition. The problem of controlling the airplane would be aggravated by predicted large favorable yaw due to ailerons and low roll damping, and it was feared that excessive sideslip might be developed before the pilot could establish a more normal flight condition by appropriate emergency procedures.

In this case, the F-86 airplane was used as a simulation vehicle to aid in selecting the minimum safe static directional stability C_{n_β}. It was not possible to match all of the predicted lateral-oscillation characteristics, but the F-86 equipment was altered to permit simulation of the low C_{n_β} and the high favorable yaw due to ailerons $C_{n_{\delta_a}}$ which were of greatest interest. A test pilot then flew the F-86 in a series of simulation flights in which C_{n_β} was varied over a range of from zero to about one-third of the normal F-86 value, while the other F-86 parameters were adjusted to give the best overall simulation of the prototype behavior. Extensive pilot comment and recorded flight data were obtained for use in conjunction with simulator studies in selecting the minimum safe directional stability.

As in many of these prototype simulations, the results suggested interesting trends. For example, Fig. 6 shows time histories of sideslip angle and pilot-applied rudder angle during a run in which the pilot was controlling the F-86 airplane against disturbances applied by the artificial rough-air generator described previously. The variable-stability equipment was set to give yaw damping and favorable yaw due to ailerons similar to that predicted for the design airplane, and the directional stability was about one-fourth of the normal F-86 value. The rough-air generator caused moderate yaw disturbances every second or two, and the resulting sideslip motions have a predominant oscillation at the airplane natural frequency, a normal occurrence when lightly damped systems are excited by random disturbances.[4]

It appears that the pilot kept changing his rudder procedure during this run, probably in a search for one that would restrain sideslip with minimum pilot effort. From 0 to 6 sec., corrective rudder motion was applied in phase with and approximately proportional to sideslip angle, and the sideslip angle was held to 1° or 2° in this manner. At about 6 sec. the pilot relaxed briefly, but around 9 sec. he had to resume more vigorous control as the sideslip increased rapidly to the right. He used a triangular-pulse type of rudder motion to return sideslip toward zero and then another to stop sideslip near zero. It is interesting to note that while these first two rudder pulses are in phase with sideslip peaks, the next pulse is well in advance of a sideslip peak—an indication that the pilot was now predicting and correcting for future sideslip oscillations. This is true to the end of the run, where the pilot applied a right rudder pulse at a left sideslip peak, indicating a 180° phase shift in anticipation of the next swing of the airplane. The nonlinear and time-varying nature of this control procedure should not be too surprising in the light of what is known of human control behavior, particularly when it is remembered that the physical system the pilot was trying to control here had both low static and low dynamic stability.

A brief analysis and discussion with Ames pilots indicates that the difficulty in controlling sideslip when C_{n_β} is extremely low is associated with several factors. First, extraneous yawing moments such as those due

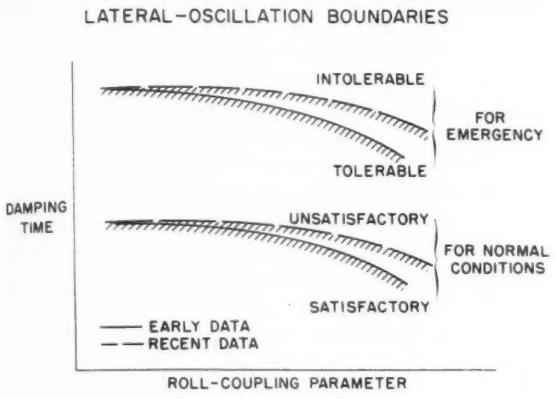


FIG. 4.

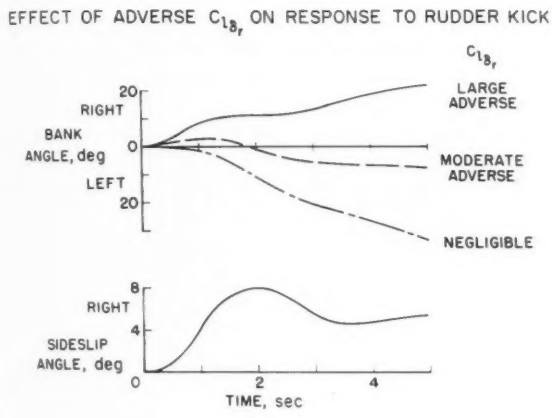


FIG. 5.

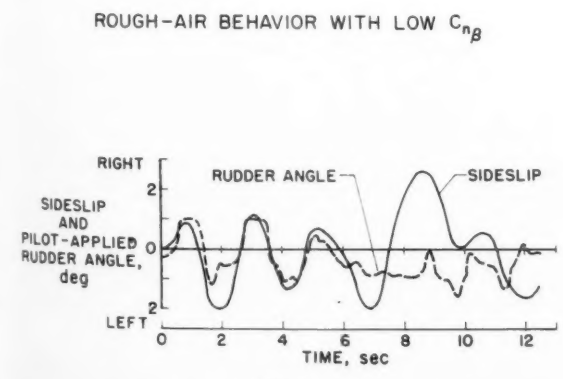


FIG. 6.

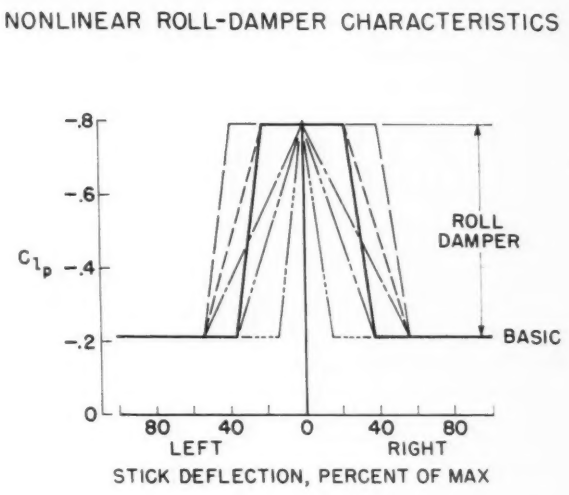


FIG. 7.

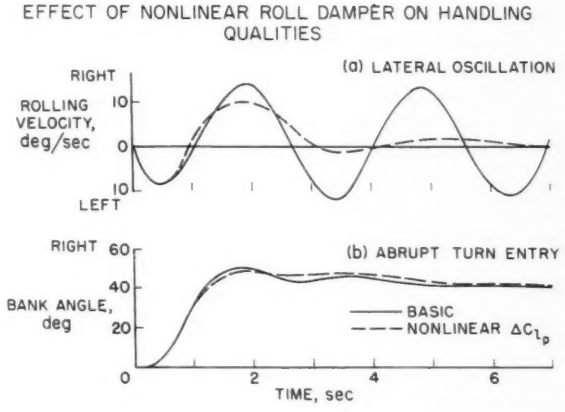


FIG. 8.

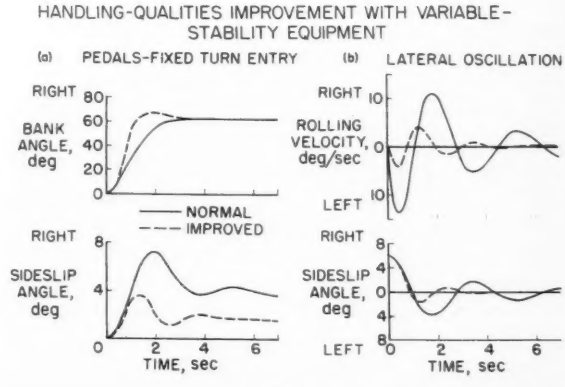


FIG. 9.

to aileron deflection or rolling velocity now excite larger sideslipping motions. Second, the detection of a steady or slowly changing sideslip angle is more difficult because of a loss in the information derived from pedal force or position—for example, the fact that the pedal force is small no longer guarantees that the eventual sideslip will be small, particularly if there is appreciable friction in the control system. Third, although the rudder deflection required to produce a given change in sideslip is smaller, the time required for this change is larger; this may account for a tendency by the pilot to speed up the response through use of larger pulse-type rudder motions, as in Fig. 6. This directional-stability problem and control procedure are reminiscent of the longitudinal control of airplanes that have marginal longitudinal stability.

In the third example, estimates of the lateral-oscillation characteristics of a proposed airplane in the landing-approach condition indicated easily excited and poorly damped motions, particularly in roll. While a yaw damper would provide good damping of an established oscillation, it appeared that objectionable rolling motions might still be excited. The contractor accordingly was interested in using a roll damper instead, since calculations indicated not only that roll-coupling and excitation would be reduced but that in this case damping of the oscillatory mode would be increased. The proposed roll damper called for automatic deflection of the ailerons in response to signals from a roll rate gyro, thus giving a large increase in the effective value of C_{l_p}, the rolling-moment coefficient due to rolling velocity. As suggested in a free-flight wind-tunnel study at the NACA Langley Laboratory,[5] the added C_{l_p} would be reduced automatically as a function of lateral stick deflection in order to avoid the sizable reduction in rolling maneuverability which would otherwise result.

The variable-stability F6F airplane was utilized to simulate the predicted oscillatory characteristics of the prototype airplane with no damper, a roll damper, and a yaw damper. In order to provide early flight experience, the F6F equipment was modified for this simulation to include a roll damper of the proposed nonlinear type. The manner in which the additional roll damping should vary with stick deflection was of interest, so a number of simple variations shown in Fig. 7 were provided. Here values of C_{l_p} for the F6F are plotted as functions of lateral stick deflection in terms of the per cent of maximum available deflection. The C_{l_p} level labeled "basic" is that used in simulating the damper-off behavior of the prototype. The hat-shaped curves, which are symmetrical about trim stick position, show the variations of C_{l_p} with stick deflection which were provided. It is seen that in all cases the roll damping is high with the stick neutral (to give good damping) and low at large stick deflections (to retain good maneuverability); the differences are in the width of the region of high C_{l_p}, and the rate at which it decreases with stick deflection.

The dark curve is representative of the optimum available variation selected in initial flights by Ames pilots and hence utilized in subsequent prototype simulation flights. The improvement in handling qualities associated with this nonlinear roll damper is illustrated in Fig. 8. The basic airplane considered here is the F6F adjusted to approximate the prototype airplane lateral oscillatory behavior with damper off, characterized by a heavily excited, lightly damped rolling oscillation. The great reduction in the oscillatory rolling velocity with the nonlinear C_{l_p} damper in operation during control-fixed lateral oscillations is readily apparent. For the time histories of bank angle during an abrupt turn entry, the same limited stick deflection was used in both cases. The resulting time required to reach or to stabilize at the desired bank angle was about the same, thus demonstrating that the reduction in C_{l_p} with stick deflection prevented any deterioration in roll maneuverability.

Evaluation of Stability Augmenters

As might be inferred from the last example, another application of the variable-stability airplanes lies in the flight evaluation of promising yaw dampers, roll dampers, and so forth, referred to in general as stability augmenters. In fact, the variable-stability equipment itself can be viewed as an unusually versatile and powerful stability augmenter. When viewed in this way, it is apparent that considerable experience in the design and evaluation of stability augmenters has been gained as a natural by-product of the other research applications. For example, in the general flying-qualities surveys, the features of the variable-stability equipment that produced behavior considered desirable by the pilots can suggest stability augmenter designs worthy of consideration for operational airplanes. As a more direct example, most of the Ames simulations of prototype airplanes have included flight evaluation of proposed stability augmenters, such as the nonlinear roll damper just discussed.

Some idea of the effectiveness of the stability augmenter combinations available on the F6F (and potentially on operational airplanes) can be gained from the fact that the Ames pilots who often fly this airplane soon learn that the inherent flying qualities can be improved appreciably by judicious selection of variable-stability settings, and they often use such settings in routine cruising flight. No reflection on the F6F-3 airplane is intended here, since its inherent characteristics can be considered normal for the type and design era, and it has obviously proved a rugged and reliable test vehicle. It is interesting to compare the lateral and directional behavior of the normal airplane with that for the optimum stability augmenter configuration as selected by the Ames project pilot from those presently available.

Example time histories for these two cases are presented in Fig. 9. For an abrupt turn entry made with the same limited stick deflection, the time to reach the desired 60° bank was cut nearly in half by the im-

provement. This is traceable primarily to the use of the nonlinear roll damper, which the pilot adjusted in this case to give a large reduction in C_{l_p} at moderate stick deflections, while retaining the adequate inherent roll damping near neutral stick position. The pedals were held fixed during this maneuver to illustrate the adverse yaw characteristics, and it is seen that the sideslip with the improved airplane was about half that for the normal airplane. This reduction is associated primarily with the moderate increase in directional stability C_{n_β} and the large increase in yaw damping C_{n_r} selected by this pilot. In the lateral oscillations, initiated by returning the controls to neutral when in a steady sideslip, the motions of the improved version are much more heavily damped and not as heavily excited, particularly in the case of the rolling motion. The stronger damping is related primarily to the large increase in C_{n_r} mentioned previously, while the lower roll excitation is due principally to the increase in C_{n_β} and to a moderate reduction in effective dihedral C_{l_β} chosen by the pilot. These changes can be summarized by saying that the pilot has used the variable-stability equipment as a stability augmenter to reduce the yaw and roll interactions and response to disturbances and to increase the originally low roll maneuverability.

Concluding Remarks

In the present paper, equipment developed at the NACA Ames Aeronautical Laboratory for varying in flight the lateral and directional stability characteristics of two fighter-type airplanes has been described briefly, with emphasis on the research-tool possibilities offered by the large number and ranges of variable-stability derivatives and associated lateral-oscillation characteristics. Several types of research applications that have been evolved through experience have been discussed, and the effectiveness of this equipment in research has been indicated by means of example problems and results. These applications included: first, flight surveys over wide ranges of lateral and directional behavior of present and future operational interest in order to illuminate potential flying-qualities problems and to provide data useful in establishing related specifications; second, flight simulation of possibly undesirable characteristics predicted for proposed airplanes in order to assist the designer; and third, flight evaluation of promising types of stability augmenters. This far from exhausts the possibilities, and it is hoped that the present review may suggest further applications of variable-stability equipment not only in research and development but also in operational aircraft.

References

[1] Kauffman, William M., Smith, Allan, Liddell, Charles J., Jr. and Cooper, George E., *Flight Tests of an Apparatus for Varying Dihedral Effect in Flight*, NACA TN 1788, 1948.

[2] Liddell, Charles J., Jr., Van Dyke, Rudolph D., Jr., and Heinle, Donovan R., *A Flight Determination of the Tolerable Range of Effective Dihedral on a Conventional Fighter Airplane*, NACA TN 1936, 1948.

[3] Kauffman, William M., Liddell, Charles J., Jr., Smith, Allan, and Van Dyke, Rudolph D., Jr., *An Apparatus for Varying Effective Dihedral in Flight with Application to a Study of Tolerable Dihedral on a Conventional Fighter Airplane*, NACA Rep. 948, 1949.

[4] Schade, Robert O., and Hassell, James L., Jr., *The Effects on Dynamic Lateral Stability and Control of Large Artificial Variations in the Rotary Stability Derivatives*, NACA TN 2781, 1952.

[5] Bird, John D., *Some Calculations of the Lateral Response of Two Airplanes to Atmospheric Turbulence with Relation to the Lateral Snaking Problem*, NACA RM L50F26a, 1950.

Superperformance Rockets for Fighter Aircraft

(*Continued from page 28*)

stages of a new airplane; increased performance becomes a serious requirement in the later operational life of the aircraft; this then results in costly and ineffective crash programs.

(4) It does not appear likely that any single rocket configuration can be made to fit into more than one airplane at present.

(5) Rockets may become standardized if the airframe manufacturer is required to make provision for them in the basic aircraft during the design phase. If this is done, it may then be possible to apply thrust augmenting rockets in the later stages of the operational life of the airplane and thus fill in the time interval between the operational obsolescence of a given model and the operational availability of the next model.

References

[1] Summary Report No. F-SU-1141-ND, GS-AAR Wright Field No. 17 *German BMW-801 Engines* (Project No. DP-34, Hq, AMC, Wright Field).

[2] McLarren, Robert, *Afterburner*, Aero Digest, Vol. 64, No. 2, pp. 60, 62–66 ff., February, 1952.

[3] Gunston, W. T., *Boosting Gas Turbines*, Flight, Vol. 61, No. 2242, pp. 36–38, January, 1952.

[4] Von Kármán, Theodore, *Jet Assisted Take-Off*, Interavia, Vol. 7, No. 7, pp. 376–379, July, 1952.

[5] Hawthorne, Randolph, *The Sprite Rocket Motor*, Aviation Age, Vol. 17, No. 4, pp. 36–37, April, 1952.

[6] Von Doenhoff, A. E., and Loftin, L. K., Jr., *Present Status of Research on Boundary-Layer Control*, Journal of the Aeronautical Sciences, Vol. 16, No. 12, pp. 729–740, 760, December, 1949.

[7] *Lift Raiser; Boundary Layer Control Studied in Cessna 309*, Aviation Week, Vol. 58, No. 22, January, 1953.

Simplified Magnesium Air-Frame Design

The use of thick-skin magnesium design techniques in the fabrication of swept and thin wings and other structural components, resulting in reductions in weight, cost, and engineering complexity.

J. P. DONALD GARGES*
East Coast Aeronautics, Inc.

(I) Introduction

There are usually sound reasons behind the trends that influence designers or industry along certain lines. In aircraft development work the most noteworthy recent changes have been in power plants and aerodynamic configurations. These changes naturally have their effect on the structural design as well. The desire to fly faster and higher has altered the appearance of the modern aircraft and has introduced widespread use of swept thin wings. Both swept wings and thin wings bring new headaches to the airplane designer. Spanwise bending of a swept wing produces high torsional loads, and the fact that the wing must be extremely thin complicates the structural designer's problem by causing especially shallow torsion boxes. As a matter of fact, the reduction of wing thicknesses also makes it more difficult for the wing to carry pure bending loads. The aircraft structural designer is also confronted with difficult problems brought about by:

(1) Aerodynamic heating of the structure.

(2) Highly critical structural weight of the increasingly large aircraft.

(3) Increased torsional and bending rigidity requirements.

Anticipating many of the above problems, both the Air Force Wright Air Development Center and the Navy's Bureau of Aeronautics initiated structural development projects as far back as 1946 to determine the suitability of a thick-skin magnesium design approach to solve some of these problems. The first part of this paper will relate the results that have been obtained from some of these already completed projects.

(II) Air Force and Navy Thick-Skin Magnesium Design Projects

The basic criterion for the design of aircraft structures is that of adequate strength with the minimum possible weight. A high percentage of the weight of an airplane is in members for which compressive buckling is a critical condition. The most effective means of boosting the allowable compressive stresses under such conditions is to employ thick cross sections. The advantage of magnesium in these applications is obvious. In addition, when minimum gage considerations are present in a design, which is often the case, considerable weight-savings are usually possible.

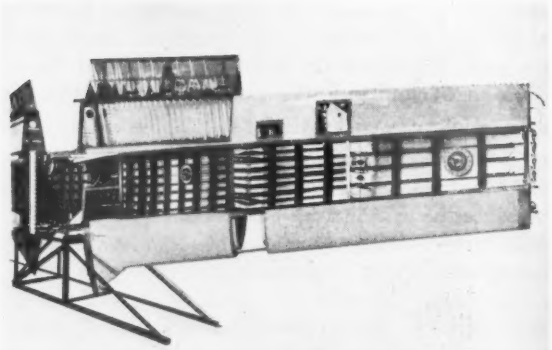


Fig. 1. Model F-80 aluminum wing panel showing internal wing structure with bottom fuel access panels removed.

Air Force F-80C Wing Project

In the WADC's program—started in 1946 to continue the development of magnesium-alloys in the primary structure of combat-type aircraft—the usual course was pursued of selecting a particular primary structural component that could be static tested, gunfire tested, and adequately service tested. After much consideration, the F-80C fighter wing was selected for this development. The development contract, which was awarded to East Coast Aeronautics, Inc., called for the most effective utilization of magnesium sheet, castings, and extrusions. The approved design was a radical departure from the conventional sheet-stringer combination normally employed in aluminum-alloy construction. Taking advantage of the greatly increased section modulus made possible by magnesium, a thick-skin design was used which, in addition to its high structural efficiency, produced several overall im-

Presented at the Aircraft Design Session, 23rd Annual Meeting, IAS, N.Y., Jan. 24–27, 1955.

* Vice-President.

portant advantages. Some of the most interesting details of this design deserve a brief discussion. Both the conventional aluminum-alloy wing and the magnesium wing utilize a two-spar type of construction and weigh approximately the same. The aluminum wing distributes the spanwise bending loads in proportions of about 66 per cent in the spar caps and 34 per cent in the skin and stiffeners. The magnesium wing reverses this procedure and absorbs only 34 per cent of the bending loads in the spar caps and 66 per cent in the sheet skin alone, since it has no stiffeners. The heaviest skin gage on the original wing was 0.051. The magnesium wing utilized skin from 0.064 to 0.375.

Fig. 1 shows the original aluminum-alloy wing with fuel cell covers removed. The magnesium-alloy wing (Fig. 2), shown here in similar condition, illustrates the degree of simplification achieved by the thick-skin design.

Fig. 3 shows a comparison of the number of parts used in the aluminum and the magnesium F-80 wings. A similar comparison in the number of fasteners used appears in Fig. 4. It is fairly reasonable to assume that the resultant savings in man-hours required to fabricate and assemble should follow a similar percentage for an equivalent number of units. The simplification in structure also resulted in a noticeable reduction in number and types of tooling and number of drawings required.

To revert to more basic structural features of a wing of this nature, thick-skin wings possess valuable aerodynamic advantages in maintaining accurate wing contours. Under static tests, the magnesium wing did not buckle until well above the flight operating loads. In the magnesium wing, no dimpling was required over the skin thickness range employed, since machine countersinking was possible throughout the structure. Fatigue cracking of thin sheet around rivets was also eliminated.

An advantage of the experimental magnesium wing which is of extreme tactical importance is the fact that, because of the elimination of most of the internal stiffeners by the thick-skin design, the internal volume available for fuel was increased to the point where an appreciable increase in range of the airplane resulted.

Gunfire tests indicated that, while not quite comparable to the gunfire resistance of the original aluminum wing, the gunfire resistance of the magnesium wing was considered entirely adequate. It should be at least equal to the resistance of 75ST, an aluminum-alloy that has come into widespread use.

An increase in torsional rigidity of approximately 50 per cent over that of the conventional wing was observed in static tests. This is clearly a major improvement toward meeting the basic requirements for increased torsional rigidity in high-performance aircraft.

The flight tests carried out on an F-80 airplane equipped with this wing indicated an increase of 5 knots in the top speed. This can be directly attributed to the smoother aerodynamic shape and absence of buckling during flight operating conditions.

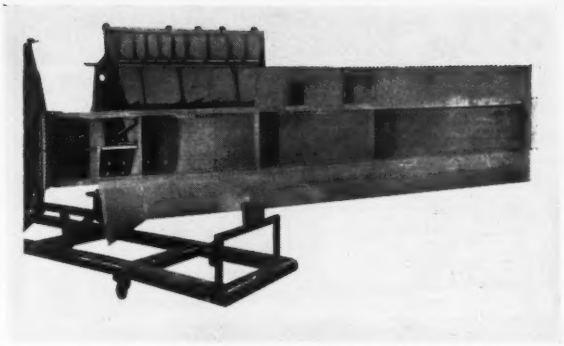


FIG. 2. Model F-80C magnesium wing panel.

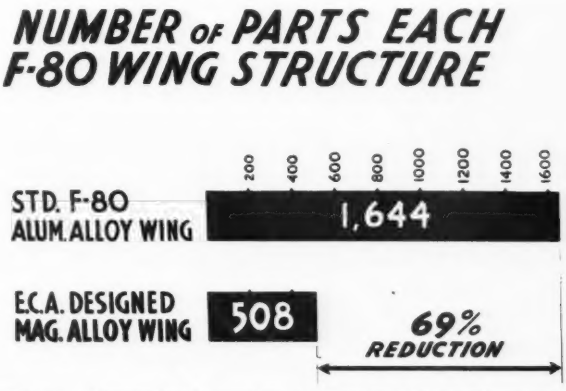


FIG. 3. Comparison in number of parts in F-80 aluminum and magnesium wings.

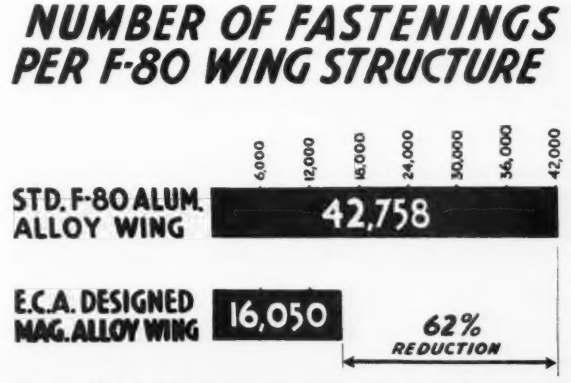


FIG. 4. Comparison in number of fasteners in F-80 aluminum and magnesium wings.

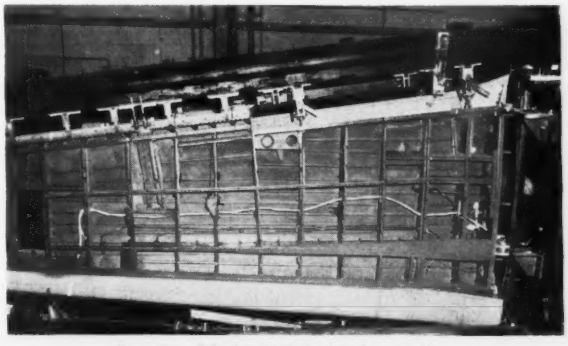


FIG. 5. Model F9F-2 aluminum wing.

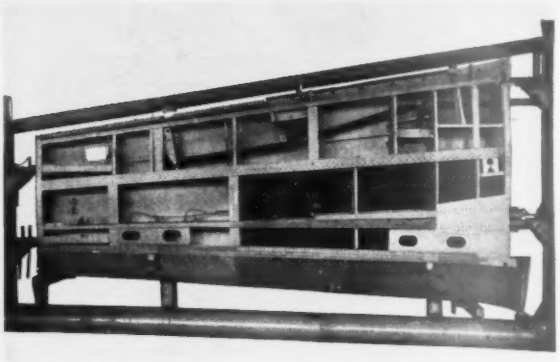


FIG. 6. Model F9F-2 simplified thick-skin magnesium-alloy wing outer panel. Bottom view with bottom skin removed.

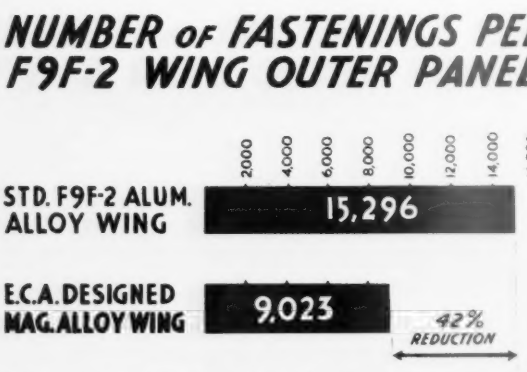


FIG. 8. Comparison in number of fasteners in F9F-2 aluminum and magnesium wings.

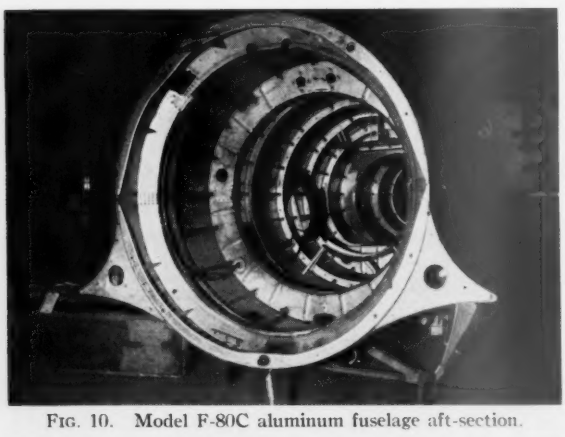


FIG. 10. Model F-80C aluminum fuselage aft-section.

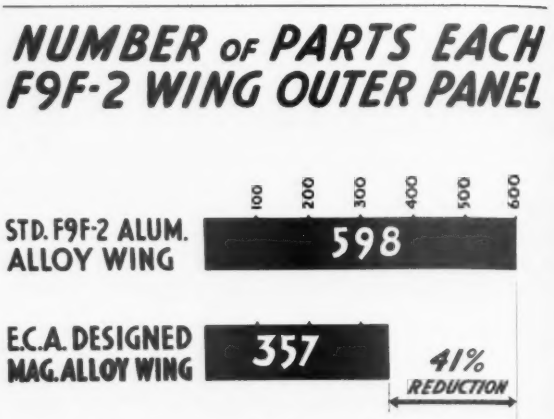


FIG. 7. Comparison in number of parts in F9F-2 aluminum and magnesium wings.

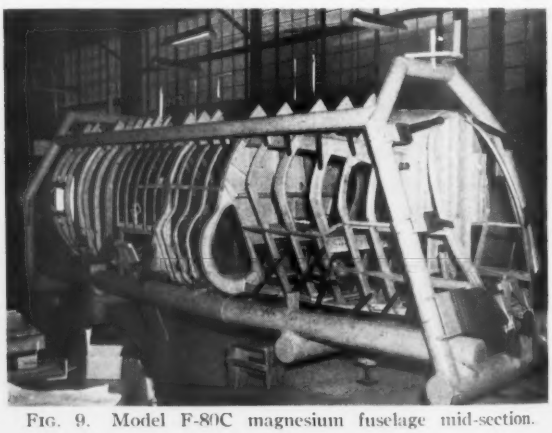


FIG. 9. Model F-80C magnesium fuselage mid-section.

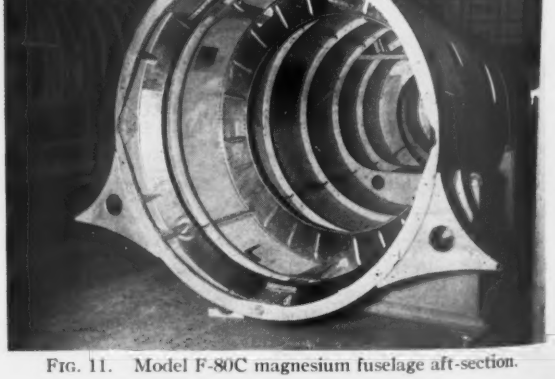


FIG. 11. Model F-80C magnesium fuselage aft-section.

Navy F9F-2 Wing Project

A project by the Structural Development Section of the Structures Branch of the Navy Bureau of Aeronautics was initiated during 1948 along lines somewhat similar to the F-80 magnesium development. The wing outer panel of the Navy F9F-2 airplane was selected to be redesigned as a thick-skin all-magnesium-alloy simplified structure.

Fig. 5 shows the conventional aluminum-alloy wing designed and built by Grumman Aircraft Engineering Corporation. It represents typical sheet-stringer construction. The folding-wing feature accounts for the somewhat more complicated structural arrangement.

Fig. 6 is a similar view of the all-magnesium wing designed and built at E.C.A. All spanwise stringers were eliminated, as were approximately half of the ribs.

Whereas the maximum skin thickness on the aluminum wing is 0.064, up to 0.188 skins are used on the magnesium-alloy version. Actual weighing of the wings showed them to be within 3 per cent of each other whereas the thick-skin magnesium wing tests indicated a torsional rigidity increase in the neighborhood of 33 per cent over the standard Grumman wing. This means better rate of roll—a quality always looked for, especially in fighter aircraft.

Fig. 7 shows the comparison of parts used on the conventional aluminum-alloy wing and on the magnesium wing. Fig. 8 shows a similar comparison in the number of fasteners used.

Because of the elimination of stringers and stiffeners and the reduction of ribs, it would have been possible to install fuel cells within the wing. Previously, only wing-tip tanks could be carried. The fuel capacity of the wings, therefore, could have been increased by approximately 42 per cent.

A service test quantity of the F9F magnesium flight wings was procured for the purpose of conducting service tests aboard carriers. These tests, which have been going on since January, 1954, should answer many of the questions the operating personnel have asked regarding this new design technique and the characteristics of the magnesium-alloy under Navy carrier service operating conditions.

F-80C Complete Airplane Project

After the successful completion of the F-80 wing project, the Air Force WADC negotiated an additional contract that called for the redesign of the entire structure of the F-80C airplane, with the exception, of course, of the wing that had already been completed. This contract, like that for the wing, was for the purpose of applying this same simplified thick-skin magnesium design technique to the fuselage, empennage, ailerons, flaps, and other structural components. One of the complicating factors of this project was the requirement for interchangeability between the redesigned magnesium and the original aluminum components. Two prototypes were required, one to be used for static test and the other to be used as a flight-test airplane.

Fig. 9 shows a view of the fuselage mid-section in the assembly fixture during construction. You will note that the thick-skin design permitted a reduction in the number of frames and the complete elimination of longitudinal stringers. However, because of the interchangeability requirement, the four main longerons were maintained in order to retain the identical attach points for the nose, mid-section, and aft-fuselage subassemblies.

Fig. 10 shows a photograph of the original aluminum aft-fuselage, revealing the usual sheet-stringer type of construction. Fig. 11 is a similar photograph of the redesigned magnesium aft-fuselage, showing how the interior structure was cleaned up by the elimination of stringers with the exception of the four main attach-longerons.

Fig. 12 gives a view of the complete airplane with the wing attached. Although it is not too apparent from this photograph, the actual surface of the aircraft presented a much cleaner aerodynamic appearance because of the thicker skins free from any dimpled rivets or attachments. The static test airplane was delivered to the Structures Lab at WADC in July, 1953, and the static tests were successfully completed approximately 3 months after their start. The flight-test article was completed and test flown during June, 1955. In this latter project, as well as in the previous F-80 wing project, the application of the thick-skin design techniques resulted in a simpler, more rugged design that improved the torsional rigidity and resulted in noticeably smoother aerodynamic surfaces throughout. Although at the time of this paper an accurate comparison of the number of parts and fasteners of the magnesium and aluminum designs had not been made, it is estimated that the redesigned magnesium components contained approximately 35 per cent fewer parts and fasteners than the original aluminum design.

(III) Convair Magnesium Floor Development

During the past few years, Convair, San Diego, A Division of General Dynamics Corporation, has carried out an extensive development program to determine optimum flooring structures for their R3Y Tradewind Sea Plane and the R4Y Transport. The R3Y is a

Fig. 12. Model F-80C complete magnesium airplane.

Navy seaplane with a cargo capacity of 48,000 lbs. The R4Y is a cargo version of the Convair Liner 340 and has a cargo capacity of 14,000 lbs. The results of these developments were covered in a paper presented at the 1954 Magnesium Association Meeting in St. Louis by Kenneth King, Fuselage Designer, Convair-San Diego.[1] During these developments at Convair, a number of different types of floor structures were examined. In deciding on the most suitable structure, the following design criteria were carefully compared: bending, impact, rolling wheel loads, and shear.

Of course the weight of the structures and the manufacturing costs were important factors, particularly in the case of the transport aircraft. Convair found that the simple design afforded by the magnesium structures was easily understood structurally and was not only the lowest in cost but the lightest and best in performing its function in the airplane. Results of the tests performed at Convair on these floor panels were put in the form of a strength/weight ratio chart covering each panel for bending and concentrated loads. Fig. 13 is a reproduction of this chart indicating the various types of floor panels tested (10 in all) and their relative strength/weight ratios, with the magnesium extrusion as the 100 per cent basis. The magnesium extruded panels are indicated, for bending loads, to be 33–65 per cent better than all other specimens except the built-up magnesium sheet and stringer combinations. I believe this chart is a good illustration of how magnesium structures can exhibit superior strength weight ratios for many applications, in spite of the fact that the basic material may not be as high on a strength/weight rate basis as some of the higher strength aluminum-alloys—such as 75ST—which may have been used in competitive structures.

(IV) New High-Strength Magnesium Alloys

Since the structural designer of today's and tomorrow's high-performance aircraft must introduce unique designs, specialized production equipment and techniques, and new materials to combat the growing complexity of modern aircraft, it seems appropriate to include in this paper a brief discussion of new high-strength magnesium-alloys that are presently available or may be available in the near future.

In the design of thick-skin structures, compressive yield is one of the most important characteristics of the material. Although most of the past designs in thick-skin magnesium have made use of FS1H24 sheet, The Dow Chemical Company's newer alloy, QZ66XA-T6, has a higher compressive yield strength and therefore is competitive with the higher strength aluminum-alloys over a wider loading range. It has a compressive yield of 35,000 lbs. per sq. in. with a density of 0.070 lbs. per cu.in., as against FS1H24's compressive yield of 25,000 lbs. per sq.in. Although these compressive yield figures are lower than those of 14ST6 and 75ST6, as indicated in the previous discussion of the Convair flooring and in the subsequent discussion of integrally stiffened thick-skin magnesium panels, the proper application of magnesium-alloys will develop strength/weight ratios for the complete structure which will be equal or superior to comparable aluminum structures.

The temperature limit for the use of magnesium is at present about the same as for aluminum—that is, in the 250–300°F. range. However, magnesium-alloys having satisfactory properties at ranges as high as 500°F. have been introduced as castings in certain new engines, and sheet and plate alloys for application at such high temperatures are ready for service testing. Dow Chemical's HK31-H24 magnesium-alloy sheet retains 55 per cent of its room temperature tensile yield at 500° F., as compared to 27 per cent for 14S and 17 per cent for 75ST6. The HK31-H24 alloy contains 4 per cent thorium and 1 per cent zirconium. Dow Chemical's magnesium-alloy HM31XA, which is the extrusion alloy containing thorium and zirconium, has a slightly higher tensile yield than the HK alloy but retains better than 50 per cent of its room temperature strength at 500°F. In the casting alloys, EZ33AT5, which corresponds to the British alloy ZRE1, retains just under 60 per cent of its room temperature strength at 500°F. This alloy contains, in addition to a small per cent of zirconium, between 2 and 3 per cent zinc and 2–4 per cent rare earth metals added as mischmetal (approximately 50 per cent cerium, 22 per cent lanthenium, 18 per cent neodynium, 6 per cent praseodynium, and lesser amounts of rare earths and impurities). This list includes just a few of those magnesium-alloys responsible for a well-founded prospect that magnesium may range about in the middle between aluminum and titanium as a material for future high-speed aircraft.

In the case of the QZ66XA-T6 alloy, some difficulties have been encountered with stress corrosion. While Dow Chemical is continually experimenting to correct this deficiency, the designer should be aware of its existence and act accordingly. Many applications involving thick gages and high loads on the compressive side may not find too serious a detriment. It is also well to note that Dow Chemical is working on new experimental alloys that appear to possess the high compressive yield of QZ66 without the stress corrosion problems of the former alloy. It is hoped that these may be available to the structural designer in the near future.

(V) Comparison of Integrally Stiffened Aluminum with Thick-Skin Magnesium Panels

Perhaps one of the logical ways to present simplified magnesium air-frame design construction for consideration on hypothetical future airplane designs is to compare the integrally stiffened aluminum-alloy type of panel now gaining in popularity with a proposed thick-skin, multispar magnesium-alloy construction for primary wing structures. As noted by Finlay,[2] "The methods producing integral stiffeners will generally produce the highest allowables at low to medium values

TABLE 1

P_i, Kips/In.	Integral Stiffeners—75ST6 t_s	L	Number of Ribs	Rib Weight, Lbs.	Multispar, Thick-Skin—QZ66 t_s	b	Number of Spars	Spar Weight, Lbs.
5.0	0.080	16.0	14	70	0.173	6.25	3	144
10.0	0.160	32.8	6	30	0.346	12.50	1	48
15.0	0.240	49.0	4	20	0.433	12.50	1	48

P_i = 5.0 net wing weight increase = 4.9 per cent; torsional stiffness increase = 33 per cent

P_i = 10.0 net wing weight increase = 1.2 per cent; torsional stiffness increase = 33 per cent

P_i = 15.0 approximate panel weight decrease = 58 lbs.; net wing weight decrease = 2.0 per cent; torsional stiffness increase = 11 per cent

of panel compressive load per inch." Kolom[5] shows that the thick-skin, multispar aluminum-alloy type of construction will become most efficient at extremely high values of compressive load per inch, specifically above 15 kips per in. Since the present strongest magnesium-alloy (QZ66XA-T6) with a compressive yield strength level of 35,000 lbs. per sq.in. and a density of 0.070 lb. per cu.in. cannot possibly compete in strength/weight with the strongest aluminum-alloy (75ST6) with corresponding values of 70,000 lbs. per sq.in. and 0.10 lb. per cu.in., it is not the purpose of this paper to show the applicability of thick-skin magnesium in the extremely high regime of compressive loading. When and if the magnesium suppliers can produce an alloy with a 45,000–50,000 compressive yield level, it would then become competitive with aluminum-alloy at all loading ranges. However, with the magnesium-alloys available at present, it can definitely be demonstrated that the thick-skin, multispar magnesium construction has certain distinct advantages over the integrally stiffened aluminum type for compressive loading ranges below 15 kips per in. Since most contemporary wing designs fall in this loading range, it is felt that the practicability of the thick-skin magnesium type is of great importance.

In Fig. 14, the assumed typical cross section for integrally stiffened panels made from 75ST6 aluminum-alloy is shown. Stiffener sizes and spacings are such as to prevent local skin buckling or stiffener crippling before column buckling is reached. A column end-fixity coefficient of 1.75 is assumed for all calculations. Based on the above assumptions, the compressive loading curves of Fig. 15 are plotted for 75ST6 panels in which the variables are rib spacing (L) and skin thickness (t_s). A skin thickness range of 0.080 to 0.240 in. was employed. Dashed lines radiating from the origin of coordinates indicate the values of allowable column stresses and effective slenderness ratios.

In Fig. 16, the assumptions made for thick plates of QZ66XA-T6 magnesium-alloy are shown. Plate buckling stresses are based on clamped-edge conditions along the spars. This assumption is founded on our extensive experience attained on similar thick-skin designs of the F-80 and F9F-2 airplanes. The compressive loading curves of Fig. 17 are plotted for QZ66 panels in which the variables are spar spacing (b) and skin thickness (t_s). A magnesium skin thickness range of 0.173 to 0.520 in. is examined in order to establish equal-weight panels with the integral stiffener configurations of Fig. 15. Dashed lines radiating from the origin of coordinates indicate the values of maximum allowable plate stresses and plate width-to-thickness ratios.

On the basis of the compressive loading curves plotted in Figs. 15 and 17, three practical examples of medium compressive loadings of 5.0, 10.0, and 15.0 kips per in. are examined in order to obtain a comparison between the two subject types of wing construction. In these examples, as applied to a typical contemporary fighter wing design, the following assumptions are made (also see Table 1):

(1) Total wing structural weight, 1,500 lbs.

(2) Mean box beam width, 25 in.

(3) Wing span, 40 ft.

(4) Unit rib weight = unit weight of false spar = 0.10 lb./in.

It is evident from the preceding examples that the thick-skin, multispar magnesium construction can, without too much difficulty, be made of equal strength and weight as the integral stiffener aluminum type in the medium compressive load range. In general, for only a slight weight penalty, a large increase in torsional stiffness (33 per cent) may be realized in the magnesium design. Also, it is possible to secure a small weight-saving if equal torsional stiffness is desired.

However, certain definite secondary structural advantages inherent in the multispar, thick-skin magnesium construction are worthy of mention. For instance, it may be stated that plate elements are more efficient in carrying distributed air and fuel loads than integral stiffeners that behave as beam-columns. Thick-skin element centroids are located closer to the mold line than equal-strength skin-stiffener elements, which makes for reduced surface compressive loading and less weight. Any auxiliary or false spars inherent in the thick-skin design are more efficient than the transverse ribs required in the integral stiffener type since these spars will help resist a portion of the wing bending moments and transverse shears. The thick-skin surface, with its bending material spread uniformly across the structural box beam, has better fatigue resistance than the integral stiffener type with its concentrated flange members. In addition, the multispar type of wing is better suited to withstand gunfire damage than the conventional two-spar box structure.

Aside from these structural considerations, certain definite economic advantages in fabrication become

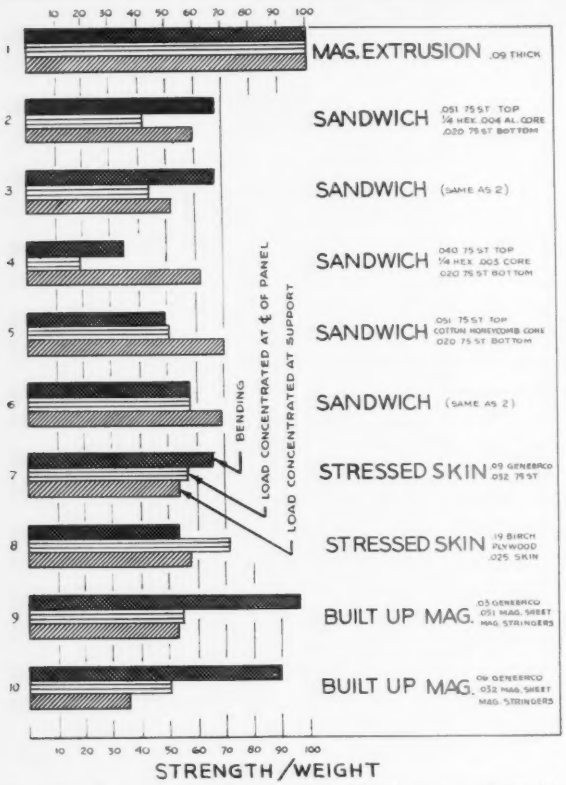
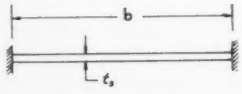

10 20 30 40 50 60 70 80 90 100
1 MAG. EXTRUSION .09 THICK
2 SANDWICH .051 75 ST TOP 1/4 HEX .004 AL. CORE .020 75 ST BOTTOM
3 SANDWICH (SAME AS 2)
4 SANDWICH .040 75 ST TOP 1/4 HEX .003 CORE .020 75 ST BOTTOM
5 SANDWICH .051 75 ST TOP COTTUN HONEYCOMB CORE .020 75 ST BOTTOM
6 SANDWICH (SAME AS 2)
7 STRESSED SKIN .09 GENEBRCO .032 75 ST
8 STRESSED SKIN .19 BIRCH PLYWOOD .025 SKIN
9 BUILT UP MAG. .05 GENEBRCO .051 MAG. SHEET MAG. STRINGERS
10 BUILT UP MAG. .08 GENEBRCO .032 MAG. SHEET MAG. STRINGERS
BENDING
LOAD CONCENTRATED AT ℄ OF PANEL
LOAD CONCENTRATED AT SUPPORT
10 20 30 40 50 60 70 80 90 100
STRENGTH/WEIGHT

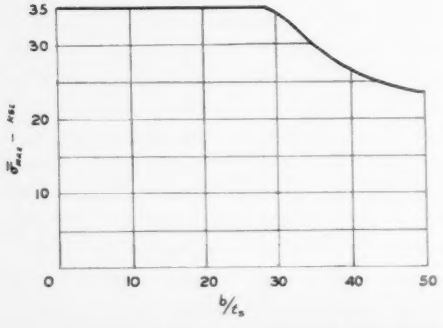
FIG. 13. Strength/weight comparison of various aircraft flooring structures.



EDGE CONDITION ASSUMED: CLAMPED

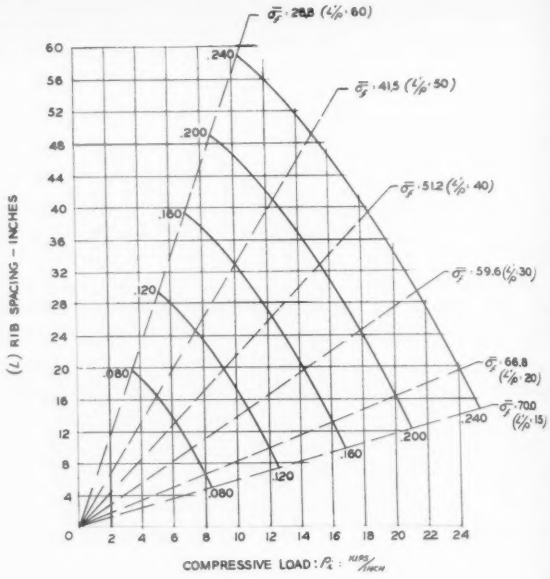
MAGNESIUM ALLOY: QZ66XA-T6
F_{cy} = 35000 psi.
DENSITY = .070 #/in³

COMPRESSIVE MAXIMUM STRESSES
REFERENCE: 4.
ASSUME SAME ALLOWABLES AS FOR ZK 60A ALLOY



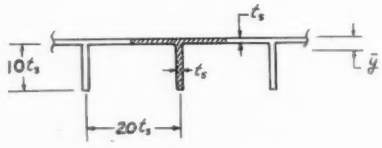
COMPRESSIVE MAXIMUM STRESSES FOR QZ66XA-T6 PLATES.

FIG. 14. 75ST6 integral stiffener elements.



COMPRESSIVE LOADING CURVES - 75S - T6 INTEGRALLY-STIFFENED PANELS.

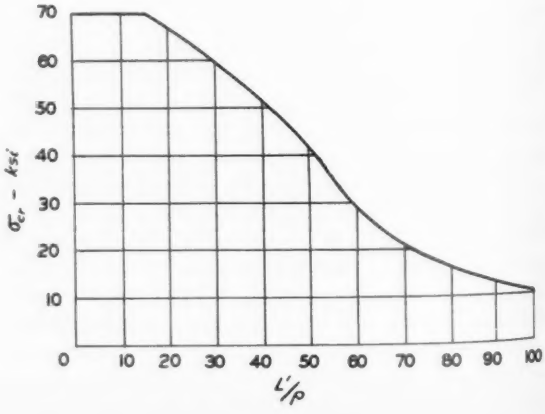
FIG. 15. Compressive loading curves, 75ST6 integrally stiffened panels.



TYPICAL ELEMENT: AREA = $30\,t_s^2$
EQUIVALENT t = $1.50\,t_s$
$\bar{y}$ = $2.33\,t_s$
ρ = $3.09\,t_s$

COLUMN ALLOWABLES - 75S-T6 EXTRUSIONS
-REFERENCE: 3

F_{cy} = 70,000 psi.



75S -T6 INTEGRAL STIFFENER ELEMENTS

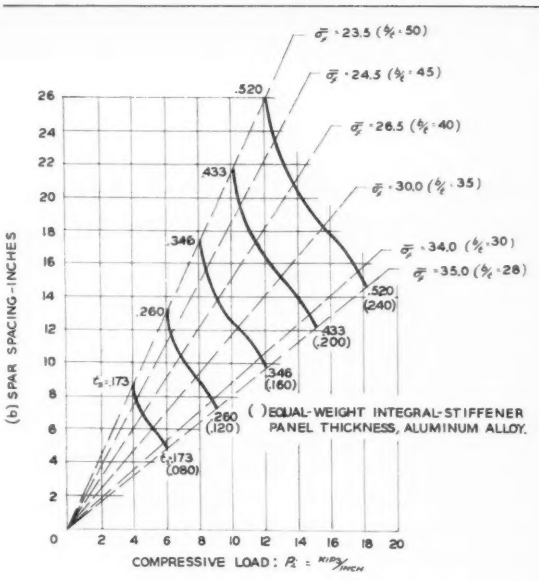
FIG. 16. Compressive maximum stresses for QZ66XA-T6 plates.

quite evident when the thick-skin, multispar design is compared with the integral stiffener type. First and foremost, it is definitely cheaper and more efficient on material to roll taper thick plates than to extrude or hog out integral stiffener panels. The vast amount of machining, straightening, and material waste typical for integral stiffener panels cannot be easily discounted. Second, the thick-skin design will employ far fewer parts in the way of auxilary spars than the integral stiffener type with its many transverse rib elements. Third, the use of straight-line elements, such as auxiliary spars, will make for cheaper tooling than is required for contoured rib members.

From the foregoing, it may be stated that the thick-skin, multispar magnesium wing structure employing QZ66 alloy can be designed as efficiently in strength, weight, and stiffness as any contemporary aluminum-alloy integral stiffener type in the medium compressive load range. In addition, certain definite economic advantages inherent in the thick-skin design make this mode of construction particularly appealing and worthy of serious consideration by the air-frame designer.

(VI) Conclusion

There have been many factors that have retarded the application of magnesium to aircraft primary structures. Problems of ductility, corrosion resistance, and fabrication techniques were among the technical ones; lack of experience of the aircraft industry with magnesium has probably been the greatest, however. Improvements in the magnesium-alloys and of chemical treatment and suitable paints and primers have contributed to the elimination of corrosion as a serious problem. Improvement in the ductility of the available magnesium-alloys has placed them in the acceptable range for aircraft structural applications. It has been the intent of this paper to present to the aircraft industry factual data based on successfully completed projects covering simplified magnesium air-frame designs and, from hypothetical studies covered in Section V of this paper, to show that thick-skin magnesium air frames can be designed as efficiently from the strength-weight standpoint as most contemporary aluminum alloy structures and may result in stiffer structures. From the standpoint of simplicity and cost reduction, it has been shown that the application of these magnesium design techniques to contemporary air frames has been responsible for the elimination of a large percentage of parts and fasteners which would have a noticeable effect on the reduction of both engineering time as well as tooling and fabrication time. The resulting parts have not been complicated by this procedure.


$\bar{\sigma}_z$ = 23.5 (5/8 · 50)
$\bar{\sigma}_z$ = 24.5 (5/8 · 45)
$\bar{\sigma}_z$ = 26.5 (5/8 · 40)
$\bar{\sigma}_z$ = 30.0 (5/8 · 35)
$\bar{\sigma}_z$ = 34.0 (5/8 · 30)
$\bar{\sigma}_z$ = 35.0 (5/8 · 28)
.520
.433
.346
.260
.173
.520 (.240)
.433 (.200)
.346 (.160)
.260 (.120)
.173 (.080)
( ) EQUAL-WEIGHT INTEGRAL-STIFFENER PANEL THICKNESS, ALUMINUM ALLOY.
(b) SPAR SPACING - INCHES
COMPRESSIVE LOAD: P_z = KIPS/INCH
0 2 4 6 8 10 12 14 16 18 20 22 24 26

COMPRESSIVE LOADING CURVES - QZ66XA-T6 THICK SKIN PANELS

Fig. 17. Compressive loading curves, QZ66XA-T6 thick-skin panels.

It is believed that application of these thick-skin design techniques to the wings of modern aircraft might reduce appreciably the necessity for complicated machine operations and expensive and scarce skin mills that are in widespread use in the so-called aluminum-alloy sculptured-skin wing design technique.

For those who are interested in designing air frames that will help to provide "more airplanes for the dollar" without compromising quality or performance, it is recommended that serious consideration be given to the simplified thick-skin magnesium approach.

References

[1] King, Kenneth, *Magnesium Floors in Convair Aircraft*, Paper presented at 10th Annual Magnesium Association Meeting, 1954.

[2] Finlay, Donald W., *Wing Design for Practical High-Speed Aircraft*, Aeronautical Engineering Review, Vol. 13, No. 12, pp. 44–46, 58, December, 1954; also Preprint No. 482.

[3] Gatewood, B. E., and Williams, E. L., *Allowable Compressive Stresses in Aircraft Structures*, Journal of the Aeronautical Sciences, Vol. 18, No. 10, pp. 657–664, October, 1951.

[4] Schuette, E. H., and McDonald, J. C., *Prediction and Reduction to Minimum Properties of Plate Compressive Curves*, Journal of the Aeronautical Sciences, Vol. 15, No. 1, pp. 23–27, 48, January, 1948.

[5] Kolom, Aaron L., *Optimum Design Considerations for Aircraft Wing Structures*, Aeronautical Engineering Review, Vol. 12, No. 10, pp. 31–41, October, 1953; also Preprint No. 419.

The mutual responsibility of the manufacturer and operator to preclude failures of a critical nature is reviewed in terms of design, manufacture, maintenance, and inspection.

High-Altitude Cabin-Pressurization Design Criteria Related to Future Transport Operations

L. M. HITCHCOCK*
Boeing Airplane Company

Introduction

Speed is the basis of the obvious appeal of air travel. This appeal will increase with higher speeds, provided comfort and safety continue at the present high level and expense is not significantly increased. The only logical way to secure large increases in speed with any type of airplane is to fly at high altitudes.

The next generation of transports will make possible a marked reduction in present-day air-travel schedules; nevertheless, reference to Fig. 1, a curve of altitude versus speed, shows that their *indicated* speed, which is the primary cause of all air loads on an airplane, is not appreciably greater than that of present air liners. Note in particular the small increase in indicated speed required to attain extremely significant advantage in true speed. This minimization of indicated speed attained by means of higher altitude results in a smoother ride, a lighter airplane, and greater operating economy. Our past experience demonstrates that the modern pressure cabin has eliminated any passenger discomfort associated with reduced ambient pressures at high altitude and has made feasible the performance gains of high-altitude aircraft. With so much to gain by flying high, it is obvious that designers will create safe airplanes to exploit these advantages. Fig. 2 indicates the trend of the design differential-pressure requirements over the last 18 years and shows that the jet transport is no departure from an orderly development in this field.

Incidents and accidents involving failures of pressure cabins on commercial transports have recently created an intense concern regarding the pressure design of presently operating transports and of future high-altitude transport airplanes. In addition, the well-known physiological problems associated with the possibility of decompression become more critical with increasing altitude. It is therefore timely to reappraise our design criteria and philosophy to make certain that they reflect our latest knowledge and experience.

In order to be safe, a pressure cabin should have the ability to withstand effectively the several types of damage which will be discussed later. To control the consequences of this damage, adequate design criteria should be established and substantiating tests run. Finally, after an airplane has been built to these standards, maintenance of the design reliability becomes the responsibility of the operator. We shall now consider these factors in more detail to show that safety and reliability of pressure cabins will result from a properly coordinated program of design, test, and maintenance.

Types of Damage

The following types of damage have historically been responsible for pressure-cabin failures or may be reasoned to have some level of probability of occurrence:

Punctures occurring in flight.

Damage occurring on the ground.

Defects in manufacturing or maintenance quality.

Material fatigue.

Fig. 3 illustrates some examples of damage which must be considered.

One of the causes of in-flight damage in the past has been the puncture of pressure cabins by broken propeller blades. Punctures may also be incurred by loss of jet-engine compressor or turbine blades, cowling, fairing, antennas, or access doors. From a realistic viewpoint it is unlikely that the possibility of failures of this type can ever be entirely eliminated. The severity of such failures has varied from an instance of rapid decompression—when a propeller failure caused loss of a large portion of the cabin roof—to incidents where small holes were made—with resultant leakage no greater than that which the cabin-pressurization system could make up. There are no known instances of loss of an aircraft from these failures.

On the ground, careless use of ground-handling equipment can produce damage that may not be reported or even discovered. In addition, rocks, ice, or foreign objects can be thrown by wheels during taxi or take-off. Such damage may not be detected prior to flight, particularly if it occurs during take-off. Damage caused on the ground may not be much of a service problem but must be considered in the design to preclude the possibility of serious consequences during pressurized flight.

Presented at the Air Transport Session, 23rd Annual Meeting, IAS, N.Y., Jan. 24–27, 1955.

* Staff Engineer—Structures, Seattle Division.

In addition to punctures or tears in flight or on the ground, the possibility of improper manufacture and maintenance must be assumed. It should be considered that substandard repairs or modifications may be made to transports during their service life. It is also conceivable that instances of corrosion may not be discovered. In order to be realistic one must consider that there is always some possibility of errors in workmanship and inspection, both during service and during the original manufacture of the airplane, in spite of the best efforts of the operators and manufacturers to prevent their occurrence.

Fatigue, the last type of failure to be discussed, is currently of tremendous interest and concern. A fundamental concept of safe design should recognize that a transport airplane, with proper maintenance and replacement of parts, will last indefinitely. Our experience indicates that cracks have occurred—and may be expected to occur—during the service life of an airplane. An airplane pressure cabin is a complex structure, with many areas of load concentration and the accompanying potential stress concentration. Provisions for the proper load redistribution around windows, doors, hatches, and other cutouts and discontinuities are made with extreme care in order to prevent undue stress concentration. Also the effects of secondary deflections and the variation of stress concentration in joints, splices, and reinforcements are given careful design consideration since it is realized that detail design is a most significant factor and is all-important to fatigue life. Yet, in spite of all these precautions, it must be recognized that cracks may occur in the pressure structure, and laboratory tests will not preclude the possibility of these cracks.

There are many environmental conditions in pressure cabins which cannot be well accounted for or tested in the initial design. These include such factors as jet-exhaust effects, induced thermal stresses, propeller buffeting, and flight-load effects. Some areas of the pressure-cabin skin will be quilted under load, and these deflections may or may not cause unstable aerodynamic forces or buffeting.

Another factor of importance is the well-known large scatter in fatigue life, although there is some evidence to indicate that this scatter may not be as great for full-scale structural sections as exist in small laboratory specimens. This scatter can be influenced considerably by differences in operating procedures of the various air lines because of variation in routes, trip lengths, types of weather, speeds, and pressurization procedures. Scatter can be further affected by variations in manufacturing quality during the fabrication of a transport and/or by repairs and modifications after the airplane is delivered to the operator. It is therefore impossible to assign a number to the point at which fatigue cracks will begin to appear. There were instances in the past when full-scale fatigue tests were run and complete reliance on airplane-life predictions was placed on the results, yet the airplanes so tested suffered most unfortunate accidents from fatigue. There is no reason to believe that complete reliance on airplane-life predictions based on analysis and testing can be made in the future any more than in the past.

On the basis of these considerations it should be conservatively assumed that punctures, tears, cracks, and other damage are inevitable during the service life of an airplane, even though extreme effort has been made to keep them to a minimum. It follows, then, that one of the primary goals should be to provide safety in spite of such occurrences.

Design Criteria

The pressure-cabin design criteria to achieve the above-mentioned goal of safety in spite of damage must obviously include the requirement of multiple-path structure. It is also evident that the pressure structure must provide a high level of tear resistance —consistent with the design and operating pressure loads—against the damage that may occur. The design criteria should also include requirements providing both a high level of fatigue endurance for the overall structure sufficient to preclude abnormal maintenance requirements and an adequate fatigue endurance after a partial failure to provide reasonable time to discover

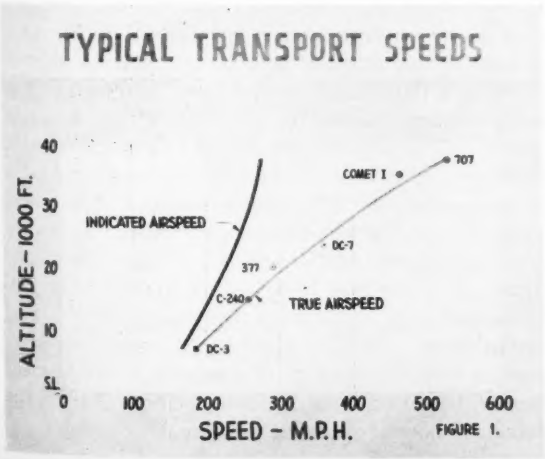


FIGURE 1.

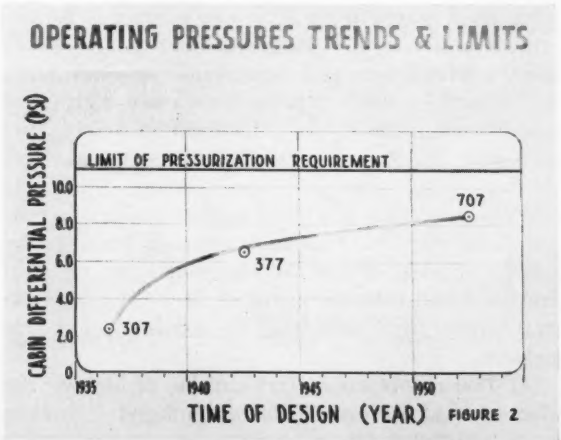
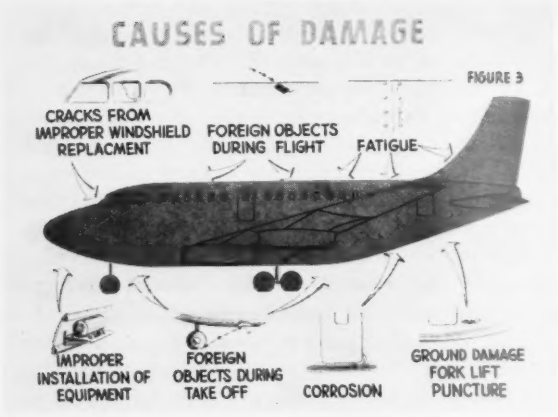


FIGURE 2



the damage. The general level of endurance should be at least comparable with successful past transports. With these thoughts in mind, the following design criteria are being used by Boeing Airplane Company to obtain a level of safety against rapid loss of pressure which is compatible with the overall aspects of high-altitude aircraft operation:

(1) Multiple-load-path structure is used around cutouts and other areas of load concentration. Fig. 4 shows a typical multiple-path design.

(2) A factor of safety of 3 is applied to the maximum operating pressure in the areas of (1) above, so that a factor of safety on the order of 1.5 will exist in the event one member of a dual-load-path structure is failed. This will provide a good level of fatigue life for the overall structure and gives adequate time to allow for discovery of a possible partial failure. Fig. 5 shows that a design factor of 3 provides a good life expectancy of a typical dual-load-path structure after failure of one member. It is evident that an adequate design factor or stress level is of great importance in that it is the major factor in determining the endurance capabilities of the structure, both before and after a crack occurs. The importance of good inspection provisions for basic structure must be emphasized if the structure is to provide a high level of safety.

Design factors of safety must be selected to assure that a consistent level of endurance will be obtained in the other areas where no load concentrations are believed to exist. For a typical longitudinal fuselage joint, as indicated in Fig. 6, a safety factor of 2.5 can provide a high level of fatigue endurance. An established level of fatigue endurance should be selected as a design basis upon which to evaluate a new design. It would be desirable if this were based on a previously successful design and were used in a comparative manner.

When pressure is combined with flight loads in general, it is believed a reasonable criterion would be for a factor of safety of 2 on the maximum operating pressure combined with the factor of safety of 1.5 on the most critical flight loads that are consistent with this pressure.

(3) Tear-resistant structure capable of limiting the effect of local damage should be employed. There is evidence from service experience that some current transports have tear-resistant structure that is effective against considerable damage. Fig. 7, showing gunfire damage of a B-29 fuselage skin sustained while the cabin was pressurized to 6.55 lbs. per sq.in., is an example. Most modern transports are of skin-and-longitudinal stiffener-type construction and are believed to be more tear resistant for longitudinal stresses than for the hoop stresses, since the longitudinal pressure loads are one-half the hoop pressure loads and there is more multiplicity of structure for longitudinal loads. Fig. 8 shows the effect of stress level on tear resistance of 24S-T3 sheet. This curve is based upon a few tests of a current Boeing program to determine the tear resistance of structure. Additional work is being done to determine if normal design practices provide tear resistance or if additional structure must be provided and what level of damage it is practical to contain. We are currently constructing a series of scaled pressure "barrels"—for testing both at sea level and in the altitude chamber—to explore further the factors influencing tear resistance.

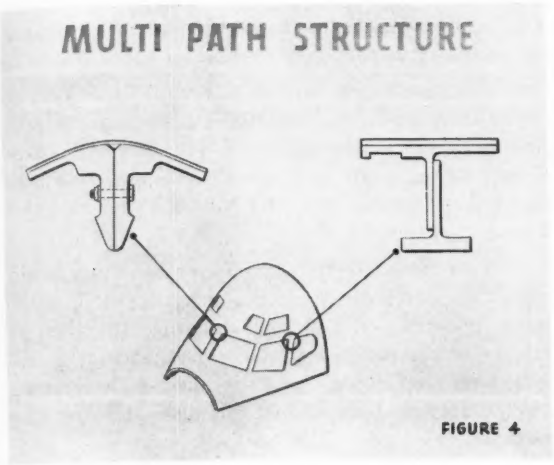
(4) Dual safety of windows should be provided for high-altitude operation where window failure can be critical. This can be accomplished by two separate windows of acrylic or glass or by the use of laminated glass windows where the vinyl inner layer is the secondary-pressure-carrying member in the event the glass fails. Either type can provide safety. Tests have shown that laminated acrylic windows often will not provide dual safety at low temperatures, since cracks in the acrylic have propagated through the vinyl with resultant complete failure.

(5) Doors, windows, and escape hatches of the plug type, in which pressure forces hold them in place, are desirable where possible. This eliminates the dependence upon hinges and latching mechanisms which are subject to fatigue failure or malfunctioning.

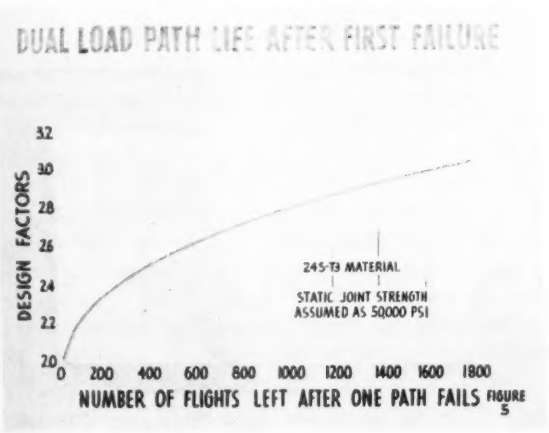
(6) "Design against fatigue" to the best of our ability must be one of the major criteria used during the detail design.

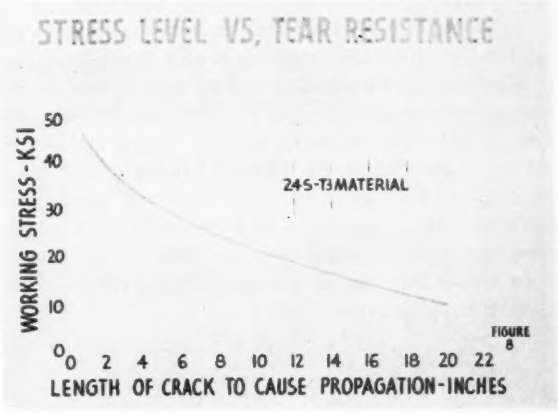
Tests to Substantiate Design Goals

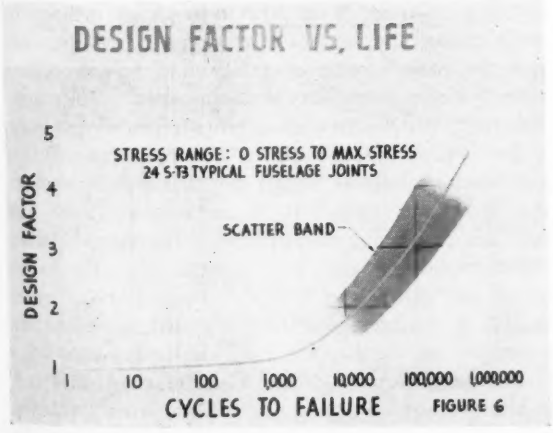
After the design criteria to assure safety and endurance of pressure cabins have been established, a comprehensive test program must be conducted to demonstrate that the criteria selected have been met. Common industry practice for a number of years has required fatigue tests of typical skin splices and joints of stiffeners and frames. Such tests were essential early in the design to establish that generally a high level of endurance of the basic structure existed. Repeated-pressure-load tests of windows, hatches, doors, and surrounding structure have been considered to be general practice in establishing the design excellence of cutout areas. It has also been a general industry practice that the fuselage, or a representative segment thereof, be tested to an ultimate factor of 2 times the maximum normal operating pressure.

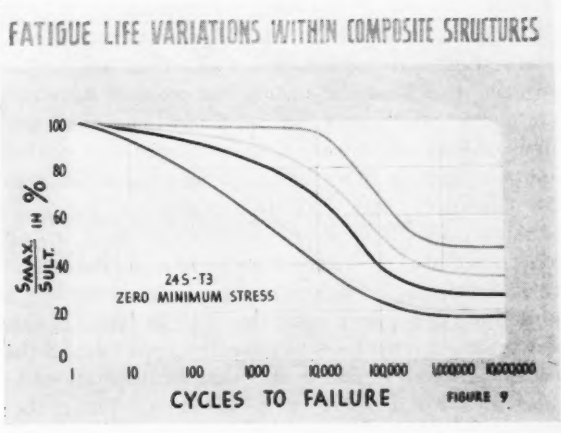

MULTI PATH STRUCTURE
FIGURE 4

TEAR RESISTANCE
FIGURE 7


DUAL LOAD PATH LIFE AFTER FIRST FAILURE
DESIGN FACTORS
32
30
28
26
24
22
20
0
200
400
600
800
1000
1200
1400
1600
1800
24S-T3 MATERIAL
STATIC JOINT STRENGTH
ASSUMED AS 50000 PSI
NUMBER OF FLIGHTS LEFT AFTER ONE PATH FAILS
FIGURE 5


STRESS LEVEL VS. TEAR RESISTANCE
WORKING STRESS - KSI
50
40
30
20
10
0
24S-T3 MATERIAL
0
2
4
6
8
10
12
14
16
18
20
22
LENGTH OF CRACK TO CAUSE PROPAGATION - INCHES
FIGURE 8


DESIGN FACTOR VS. LIFE
DESIGN FACTOR
5
4
3
2
1
STRESS RANGE: 0 STRESS TO MAX. STRESS
24 S-T3 TYPICAL FUSELAGE JOINTS
SCATTER BAND
1
10
100
1,000
10,000
100,000
1,000,000
CYCLES TO FAILURE
FIGURE 6


FATIGUE LIFE VARIATIONS WITHIN COMPOSITE STRUCTURES
SMAX / SULT. IN %
100
80
60
40
20
0
24S-T3
ZERO MINIMUM STRESS
1
10
100
1000
10,000
100,000
1,000,000
10,000,000
CYCLES TO FAILURE
FIGURE 9

In the light of recent service experience and considering the consequences of failures of high-altitude pressure cabins, it is believed that additional tests on composite pressure structures should be conducted to show that pressure structures are satisfactory, even though an extreme effort has been expended during the detail design to provide assurance of structural integrity. In the past, reliance upon ultimate-strength tests of airplane components has been used in many cases as a measure of structural adequacy. Service experience has shown many cases where components on an airplane have satisfied ultimate-load tests only to experience fatigue damage after relatively few hours of operation. This is readily explained by the effects of the varying amounts of stiffness occurring at joints and cutouts, as well as the effects of stress-concentration factors. Individual parts of a composite structure may have the large variation in fatigue life shown in Fig. 9. However, in static test of the composite structure, this variation in the strength of individual parts is not apparent because of local yielding at points of high stress, and the point of static failure may have no relationship to the results obtained from fatigue tests. It is therefore believed that cyclic-pressure tests must be conducted on a composite pressure structure to establish the structural ruggedness of a pressure cabin. It is recognized that each detail of a composite structure has its own individual *S-N* curve, and fatigue tests must include representative areas of critical portions of the structure. It is also believed necessary that tests be conducted to determine the effect of punctures, tears, or fatigue cracks on such structure while under pressure. The following tests are believed by Boeing to be necessary to assure a sound pressure structure for high-altitude operation:

(1) Critical areas of a complete pressure cabin should be carefully checked to determine the magnitude of stresses under pressure. This can be accomplished by use of strain gages, stress-measuring paints, or other suitable devices. Such a test program will give some early indication of areas of concern and what steps should be taken to reduce any high stresses that may be observed.

(2) Since it is now generally agreed that repeated-load tests should be conducted of all critical areas on an airplane, this must also include the pressure structure. For a wing, which today has relatively few cutouts and areas of load concentration, it is believed that critical joints, splices, or other areas can be fatigue tested in the laboratory with good representation. However, pressure cabins have many cutouts and areas of load concentrations. It is difficult to simulate all the critical areas satisfactorily, other than by pressure cycling a section of the pressure cabin itself. The extent of this test specimen must be determined by reviewing all the critical areas and making sure that representations of those areas are included in the specimen. The cyclic-test section should be large enough at least to contain representative specimens of all questionable areas. In some instances, it may be desirable to use a complete fuselage. These tests must not be considered as establishing the actual number of hours of fatigue life but rather that the failures that do occur will not propagate seriously before being discovered. They will point out the critical areas, the type of failures resulting, and the necessary inspection procedure for the operators to follow.

The tests should be conducted until many failures have occurred in the specimen and they have been revised to the point of achieving a long life or until such a large number of cycles has been sustained that it appears reasonable to stop.

(3) Tear-resistance tests should include the puncturing of various portions of the pressure cabin, while under pressure, with holes simulating the level of damage of the design criteria. These should be conducted on the full-scale test specimen. The pressure selected for the tests should simulate the operating condition.

(4) It has been Boeing's practice to proof pressure test each transport airplane to 1.5 times the maximum operating pressure before delivery. This provides assurance that all doors and windows have been properly installed and that all seals are satisfactory.

It is believed that such a test program will provide real assurance that the cabin design is sound. However, we must not be lulled into a false sense of security. Such tests will provide important information as to critical areas to inspect and observe during the useful life of the airplane and probably will eliminate any serious design deficiencies. As pointed out earlier, there may still be other areas where fatigue cracks may occur in service, perhaps because they were not included in the specimen or because environmental conditions were not perfectly duplicated.

Maintenance of Safety and Reliability During Service Life

The preceding discussions have dealt with the provisions for delivery of an airplane with a safe and long-lasting pressurized-cabin structure. After delivery of the airplane, the control of damage to the structure and the maintenance of safety and endurance are logically the responsibility of the operator. The manufacturer recognizes his responsibility to provide guidance to the operator during the initial service period, utilizing the development-test results for the specific airplane and experience gained from previous airplanes. In addition, continuing coordination is necessary between the manufacturer and the operator, after the initial service period, in order to modify inspection and maintenance procedures as will be indicated by the service experience on the airplane. The extensive knowledge of structural details, design considerations, and test results possessed by the manufacturer, when combined with an aggressive and alert inspection program by the air-line operator, will produce a level of safety above question.

It is believed that past practices have been in accord with the above discussion and that the structural safety level of United States commercial transports has been high. However, it cannot be overemphasized that the maintenance of safety depends upon the operator's vigilance and alertness and that, if extreme care is exercised to provide a high level of endurance to the structure, the local fatigue failures that may occur during the service life of the airplane will be found long before any danger exists.

Conclusion

The problems associated with high-altitude flight of future transport airplanes and the types of damage which can occur to pressure cabins have been presented.

The design criteria necessary to provide safety and endurance of the overall structure, with the full recognition that some level of damage in the nature of punctures and/or tears should be contained, have been outlined. Development tests to demonstrate that the design goals have been reached and the coordination of these test results with the maintenance and inspection procedures for the airplane have been discussed. It is pointed out that United States transports in operation to date have had a high level of structural safety and endurance. It is concluded that pressure cabins of future transports designed for operation at high altitude must be equipped with the same high level of structural safety and that this safety can and will be achieved in a rational manner, by use of sound criteria, adequate testing, and vigilant maintenance.

IAS Preprints

(See also page 130)

Preprints of Fifth International Aeronautical Conference Papers Currently Available

		Member Price	Nonmember Price
567	Operating Experience with Turbo-Prop Aircraft—Peter G. Masefield.	$0.85	$1.30
566	Inlet Duct-Engine Flow Compatibility—J. S. Alford.	0.50	0.85
565	Airline Use of Elementary Statistical Methods in Aircraft Performance Measurement—W. C. Mentzer and F. S. Nowlan.	0.65	1.00
564	Contributions to Fluid Mechanics from Shock Tube Research—I. I. Glass and G. N. Patterson.	0.75	1.20
563	Design of High Speed Aircraft—E. H. Heinemann.	0.65	1.00
562	Fatigue of Aircraft Pressure Cabins—Percy B. Walker.	0.65	1.00
561	Combustion for Aircraft Engines—Walter T. Olson.	0.65	1.00
560	Low Consumption Turbine Engines—Adrian A. Lombard.	0.50	0.85
559	Jet Noise—F. B. Greatrex.	0.65	1.00
558	Some Influences of Equipment Installations and Systems on Aircraft Design—Charles F. Joy.	$0.50	$0.85
557	On the Behaviour of Boundary Layers at Supersonic Speeds—R. J. Monaghan.	0.85	1.30
556	Stress Analysis of Multi-Web Boxes—W. S. Hemp.	0.65	1.00
555	Some Results of the Princeton University Smoke Flow Visualization Program—David C. Hazen.	0.50	0.85
554	Hypersonic Flow—Lester Lees.	0.75	1.20
553	Power Plants for Supersonic Flight—Eric S. Moult.	0.65	1.00
552	Design of Large Helicopters—Bartram Kelley.	0.50	0.85
551	Power Control Systems for Aircraft—John W. Ludwig.	0.50	0.85
550	The Interaction Between Shock Waves and Boundary Layers—D. W. Holder.	0.75	1.20

Preprints should be ordered by number from:

Preprint Department, Institute of the Aeronautical Sciences

2 East 64th Street, New York 21, N.Y.

IAS News

(*Continued from page 13*)

"patent award" from the company for improving an electric generator used in military tanks. Jointly with another engineer, who received a similar award, he designed a slip clutch and vibration damper which enables the generator to operate while submerged in water.

▸ **W. A. Patterson** (M), President of United Air Lines, Inc., has been elected Chairman of the Industry Advisory Committee of the Flight Safety Foundation.

▸ **Lieutenant General Donald L. Putt** (F), Deputy Chief of Staff for Research and Development, USAF, has received the honorary degree of Doctor of Engineering from the Polytechnic Institute of Brooklyn.

▸ **Ted F. Walkowicz** (M), a member of Laurance S. Rockefeller's staff in New York, has been elected to the Board of Directors of Piasecki Helicopter Corporation.

▸ **Charles H. Zimmerman** (AF), Assistant Chief of the Stability Research Division, Langley Aeronautical Laboratory, NACA, received his Master of Science degree from the University of Virginia June 12.

Members on the Move

The purpose of this section is to provide information concerning the latest affiliations of IAS members. All members are therefore urged to notify the News Editor of changes as soon as they occur.

Colonel Albert A. Arahym (AF), who has been serving as special assistant to Lt. Gen. Thomas S. Power, Commander of the USAF's Air Research and Development Command in Baltimore, has also been named Chief of ARDC's Office of Information Services.

Winfield H. Arata, Jr., MIAS, has joined Fairchild Aircraft Division as Chief of Operations Engineering in the new Military Relations Department. Formerly with Lockheed, he headed the Program Committee for the recent International Aeronautical Conference in Los Angeles.

Lt. Gen. Thomas S. Power, USAF, Commander of the Air Research and Development Command, presents the Meritorious Civilian Service Award to Jean A. Roché, AFIAS, for his outstanding contributions to the design of military aircraft. Mr. Roché is Aeronautical Development Engineer in the office of the Air Force Development Field Representative, NACA, Langley AFB, Va.

Irving L. Ashkenas (M) has been promoted to Chief Engineer of Control Specialists, Inc., Inglewood, Calif. Before joining the company he was Chief of the Aerodynamics Department of Northrop Aircraft, Inc.

Laurie J. Bayliss (M), Technical Publicity Manager, Fielding and Platt, Ltd., Gloucester, England, has been elected an Associate Member of the Institution of Mechanical Engineers, London.

Samuel M. Berkowitz (AF) has been promoted to the post of Principal Engineer, Aeronautics Section, The Franklin Institute, Philadelphia.

Raymond C. Blaylock (AF), Chief Engineer, Chance Vought Aircraft, Inc., has been promoted to Vice-President—Engineering.

Richard G. Bowman (M), Assistant Chief Engineer of Republic Aviation Corporation since 1950, has been named Assistant Chief Engineer for Production. He joined the company in 1935.

John F. Brahtz (AF), Associate Professor of Engineering, University of California at Los Angeles, has resumed full-time duties with the teaching and research staff. For the past year he was associated with the Aerophysics Development Corporation, conducting an Air Force survey of problems and research information pertaining to aerodynamic heating of aircraft and missile structure.

Gerald B. Brophy (AM), General Counsel and a Director of North American Aviation, Inc., has been elected a Vice-President.

Lieutenant (j.g.) John M. Brueger (TM), formerly with the U.S. Navy Shipbuilding Scheduling Activity, Philadelphia, has joined the Pratt & Whitney Aircraft Division, United Aircraft Corporation, as an Engineer.

Henry Burlage, Jr. (M), Assistant Professor of Aeronautical Engineering, will direct the operation of Case Institute of Technology's new Propulsion Laboratory. The $250,000 soundproof building will contain three wind tunnels and test cells for studying performance characteristics of small turbojet, ram-jet, pulse-jet, and rocket engines.

William B. Bergen (AF) has been elected Executive Vice-President of The Glenn L. Martin Company. He also will continue his duties as Vice-President—Operations. He has been with Martin since his graduation from M.I.T. in 1937.

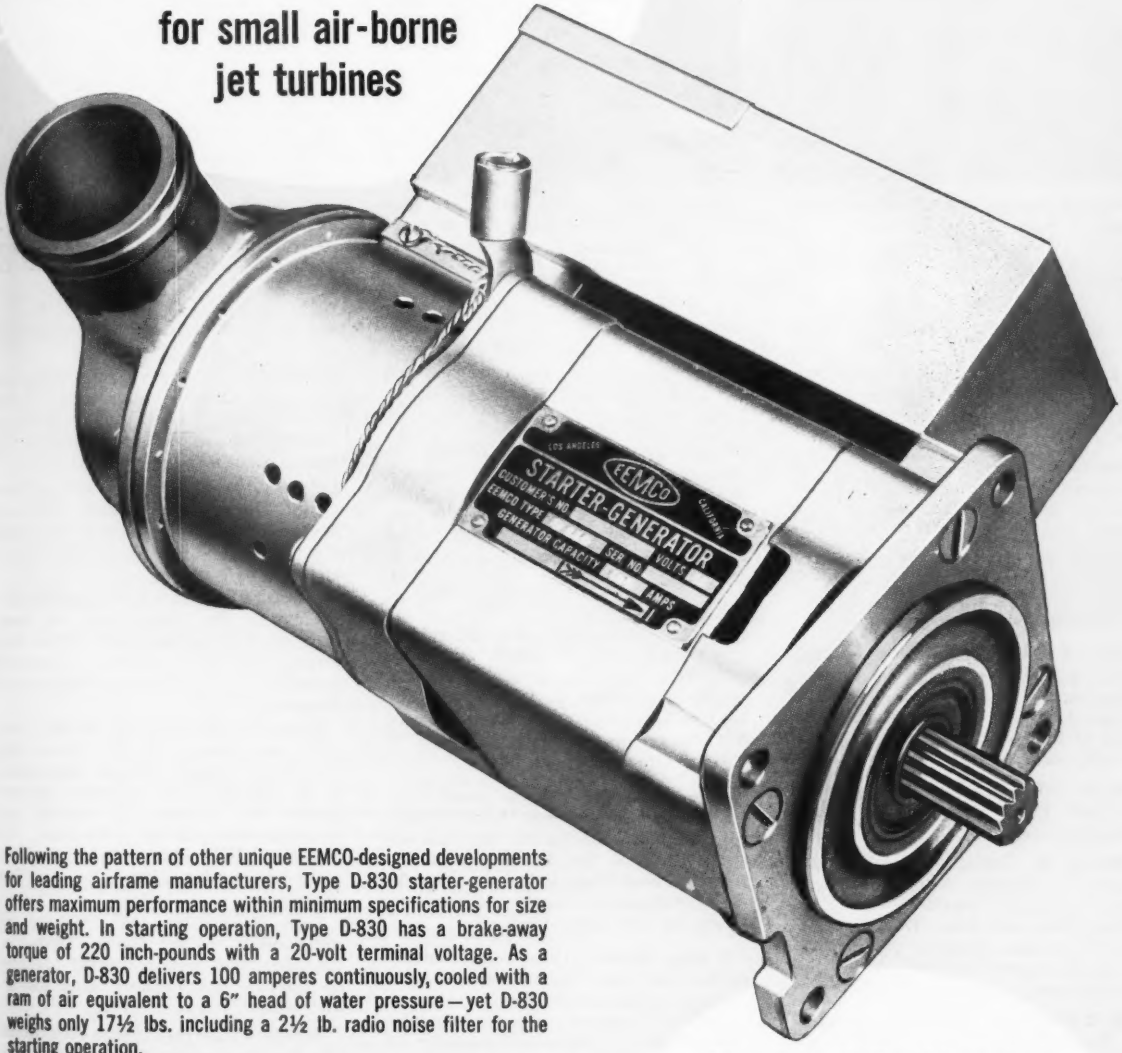
technical bulletin

a New

High-output, Light-weight

STARTER-GENERATOR

for small air-borne jet turbines



Following the pattern of other unique EEMCO-designed developments for leading airframe manufacturers, Type D-830 starter-generator offers maximum performance within minimum specifications for size and weight. In starting operation, Type D-830 has a brake-away torque of 220 inch-pounds with a 20-volt terminal voltage. As a generator, D-830 delivers 100 amperes continuously, cooled with a ram of air equivalent to a 6" head of water pressure—yet D-830 weighs only 17½ lbs. including a 2½ lb. radio noise filter for the starting operation.

The high output of EEMCO Type D-830 starter-generator in relation to its weight is typical of the many products designed, developed and produced by EEMCO for leading airframe manufacturers. Constant search for new materials and methods has resulted in production of highly efficient actuators, motors and starter-generators that meet specifications for all late designs of supersonic aircraft and guided missiles.

PROJECT ENGINEERS are invited to review the specifications of these proven EEMCO precision products before ordering new designs. Substantial savings in development time and cost can often be effected by adapting a tested EEMCO product with but minor changes to meet new conditions. Your inquiry is invited.

Electrical Engineering and Manufacturing Corp.

4612 West Jefferson Boulevard
Los Angeles 16, California
Telephone REpublic 3-0151

Designers and producers of motors, linear and rotary actuators

Adolph Burstein, AFIAS, has been promoted to Assistant Chief Engineer of Convair, San Diego, A Division of General Dynamics Corporation. He joined Convair in 1940.

Alexander H. Flax, MIAS, has been named Assistant Director of Cornell Aeronautical Laboratory, Inc. He has headed aerodynamic research there since 1949 and won the Sperry Award for 1949.

A. W. (Tony) LeVier, MIAS, pioneer in supersonic flight, has been named Director of Flying Operations by Lockheed Aircraft Corporation after 10 years as Chief Engineering Test Pilot.

John F. Ceccarelli (M) has joined Ozone Metal Products Corporation, Ozone Park, N.Y., as Landing Gear Engineer. Formerly, he was Manager of Engineering and Development, Electrol, Inc., Kingston, N.Y.

Harold A. Cheilek (M) has been placed in charge of the Aero-Mechanics Department of Cornell Aeronautical Laboratory, Inc.

Harold M. DeGroff (M), Associate Professor, has been named Head of the School of Aeronautical Engineering at Purdue University.

Fred N. Dickerman (F) has joined Lockheed Aircraft Corporation as Chief Preliminary Design Engineer of the Georgia Division. He was formerly Director of Engineering of Chance Vought Aircraft, Inc.

Daniel J. Fink (M) has been promoted to Chief Project Engineer of Allied Research Associates, Inc., Boston.

Edward E. Foster (AF), Executive Engineer of Cornell Aeronautical Laboratory, Inc., is organizing an Engineering Design and Shops Department to continue services formerly provided by the Development Division, which has been dissolved.

Mark G. Foster (M), former Head of the Development Division of Cornell Aeronautical Laboratory, Inc., has been assigned to the staff of the Director's Office.

S. G. Frank Hass, Jr. (AF), Chief of Preliminary Design, has been appointed Chief Development Engineer of Convair, San Diego, A Division of General Dynamics Corporation. A graduate of Tulane University, he joined Convair in 1939 as a Structures Engineer.

Paul E. Hovgard (F), who recently joined Kellett Aircraft Corporation as Director of Research, Development, and Engineering, has been elected a Vice-President. He formerly was Head of Rotary Wing Aircraft Design, Research Division, Navy Bureau of Aeronautics.

Robert W. Kluge (M), Guided Missiles Manager of Cornell Aeronautical Laboratory, Inc., has been named Head of a new Weapons System Design Department.

Lieutenant Commander William H. Livingston, USN (M), is now Executive Officer, Fighter Squadron 82, c/o Fleet Post Office, New York, N.Y. He was formerly CV Project Officer, Flight Test Division, Naval Air Test Center, Patuxent River, Md.

Jack Mason (AF), of Convair-San Diego, has been appointed to the staff of Vice-President R. C. Sebold and given supervision over all engineering facilities. Jointly with Grant D. Christensen (M), he also supervises all airplane projects. Mr. Mason was formerly Manager of Convair's low-speed wind tunnel.

Alfred M. Nelson (M) has joined Aerojet-General Corporation, Azusa, Calif., as a Technical Specialist. He was formerly Chief of the Nuclear Propulsion Branch, Power Plant Laboratory, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.

F. Glen Nesbitt (M) has been promoted to Assistant Sales Manager of the Aeronautical Equipment Division of the Sperry Gyroscope Company. He will supervise sales of flight and engine instruments.

J. Gilbert Nettleton, Jr. (AM), formerly Director of Military Relations, has been named Assistant to the President of Northrop Aircraft, Inc.

William J. O'Donnell (M), Chief Development Engineer of Republic Aviation Corporation for the past 10 years, has been promoted to Assistant Chief Engineer for Development and Experimental Work.

Edward M. Owen (M), formerly Assistant Director of Military Relations, Northrop Aircraft, Inc., has joined Rheem Manufacturing Company as Manager of its Washington office.

Edward L. Reiss (TM), Research Assistant in the Department of Aeronautical Engineering, New York University, has been named a Research Associate in the Institute of Mathematical Sciences, N.Y.U.

James W. Salassi (TM), former Navy pilot, has joined the AC Spark Plug Division of General Motors Corporation as an Aviation Sales Engineer. He will handle AC's commercial aviation and air-line business on the West Coast. He was formerly a Power Plant Engineer with United Air Lines, Inc., in San Franciso.

Leon N. Swisher (M), Manager of Aeronautical Sales, Sperry Gyroscope Company, has been appointed Manager of Sperry's Northwestern sales district with headquarters in Seattle.

William P. Thayer (M) has been elected Vice-President—Sales and Service, Chance Vought Aircraft, Inc. He was formerly Sales and Service Manager.

Corporate Member News

• **Aerojet-General Corporation . . .** Emerson S. Reichard, Jr., has been elected Assistant Secretary of this corporation, which is a subsidiary of The General Tire & Rubber Company. He continues as Manager of the Contracts Division.

• **Aeronca Manufacturing Corporation . . .** Aeronca's recently purchased Industrial Research Laboratories in Baltimore, now working on radar and guided missiles, have developed a trainer for radar, bombing, and navigational instruction. The company also has developed for use in the trainer a new television tube that shows 3,000 lines across the face, as compared with the usual 500 lines.

• **Air Associates, Inc. . . .** A device that detects the presence of liquid in 0.4 sec. or

450° F Tachometer Generator

meets modern jet engine requirements

Military specification numbers as used herein are for purposes of product identification only and do not necessarily imply specification conformity.

For use on high performance jet aircraft, the new Jack & Heintz Model H60-164 is a two-pole tachometer generator designed to meet MIL-G-9398.

By utilizing special design elements, this generator operates accurately at the higher altitudes and critical heat associated with advanced flight. It provides reliable and accurate engine speed indication not attainable through the use of present conventional units at a temperature of 450° F.

The special design features which enable J & H to give this performance are:

1. Heat-treated, magneto-type ball bearings.
2. Teflon-insulated magnet wire.
3. Wide temperature range greases for operation from −90° F to +525° F. *The new J & H unit has a breakaway torque of only 1 to 2 inch-pounds after 48-hour soak at −90° F as contrasted to the specified 12 inch-pounds.*

In the past five years, Jack & Heintz has supplied over 100,000 small, lightweight, permanent-magnet a-c tachometer generators to the Military, aircraft engine and accessory manufacturers and commercial airlines. The entire product line includes *sensing units* and *power sources* for:

1. Rpm indication
2. Propeller synchronization
3. Aircraft engine analyzers
4. Electronic jet-engine fuel controls
5. Turbine power packages

Whether you want a tachometer generator or any type of small permanent-magnet a-c generator, look to J & H for the answer. For complete information, write Jack & Heintz, Inc., 17632 Broadway, Cleveland 1, Ohio. Export Department: 13 East 40th Street, New York 16, N. Y.

©1955, Jack & Heintz, Inc.

ENGINEERS: Write for free booklet describing unusual opportunities for you at Jack & Heintz.

JACK & HEINTZ *Rotomotive* AIRCRAFT EQUIPMENT

These two giant presses at the Aluminum Company of America's Cleveland Works are now turning out large light-alloy forgings, such as wing spars, for use in aircraft construction. Built under the USAF Heavy Press Program, the 35,000-ton capacity press in foreground and the 50,000-ton press in rear are capable of making larger and more precise forgings than were possible formerly.

the absence of liquid in 5 sec. is in production. It is used in fuel systems and in automation processes.

• **Allison Division of General Motors Corporation . . .** The Civil Aeronautics Administration has certificated Allison's Model 501 turboprop engine for commercial operation. The 501 is used in Lockheed's C-130 Hercules and is proposed for the new Lockheed Electra ordered by American Airlines, Inc.

• **Aluminum Company of America. . .**The U.S. Air Force's Heavy Press Program, on which the Government expects to spend $279,000,000, took its biggest step forward May 5 when USAF Plant No. 47 was placed in operation by Alcoa. Flanked by several hundred officials and aviation leaders, Air Force Secretary Talbott pressed the buttons that put the massive 50,000-ton and 35,000-ton hydraulic forging presses into action. The $40,000,000 plant is composed of five main buildings, which, combined with the adjacent forging facilities of Alcoa's Cleveland Works, provide an aluminum forging area under roof of about 28 acres. Although one 35,000-ton press and a smaller press were already in use elsewhere, Plant 47 was the first complete forging unit built and put into operation under the auspices of the Heavy Press Program. The giant presses, weighing more than 6,000 tons each, tower nearly five stories above floor level and extend another three stories below ground. The large precision forgings they can produce will mean stronger, lighter, and less expensive components for all types of military aircraft. One-piece construction of parts will be facilitated, and the precision obtainable by using 35,000 and 50,000 tons of forging pressure will reduce the requirements for expensive machining. The new forging presses will permit lower cost, quantity production of light-metal structural members with the high strength-to-weight ratio needed for construction of very thin wings for high-speed aircraft. . . . Alcoa has announced plans to build the widest hot-sheet rolling mill ever designed for the aluminum industry at its Davenport (Iowa) Works. The $20,000,000 installation will roll sheets 160 in. wide. . . .The largest aluminum plate stretcher also will be installed at Davenport by agreement with the Air Force. Capable of exerting a two-way pull of 16,000,000 lbs., the $10,000,000 worth of new equipment will enable Alcoa to produce heavy, heat-treated aluminum plate in record-breaking sizes.

• **American Airlines, Inc. . . .**Major Gen. John B. Montgomery, until recently Commander of the Eighth Air Force, has been elected Assistant Vice-President—Operations.

• **Chance Vought Aircraft, Inc. . . .**A new supersonic jet fighter designed to operate from carriers has been flight tested successfully at Edwards Air Force Base. Successor to a long line of Navy fighters, the Chance Vought XF8U-1 has thin sweptback wings, mounted high on the fuselage, and a low horizontal tail. Its short, pointed nose offers good visibility. It is powered by the Pratt & Whitney J57-P-4 turbojet engine with afterburner.

• **Convair, A Division of General Dynamics Corporation. . .**A large cell for testing effects of extreme high and low temperatures on aircraft structures and systems is now in operation at Convair's San Diego plant. The cell is 20 ft. long, 10 ft. wide, and 10 ft. high—capable of accommodating a full-size section of an airplane. Temperature in the chamber can be changed from 300° F to 100° below zero.

• **Cornell Aeronautical Laboratory, Inc. . . .** The North American F-100 supersonic fighter will receive more than 100 hours of flight testing aimed at the complete flight determination of the longitudinal and lateral stability derivatives for a fighter over Mach Number ranges for which these data are not in existence. Cornell pilots are flying the Super Sabre at Edwards Air Force Base under a contract with Wright Air Development Center. . . .The Laboratory in Buffalo has installed an electronic digital computer to speed up wind-tunnel testing.

• **Curtiss-Wright Corporation. . .**An electronic flight simulator for training crews of the Boeing B-52, the world's largest and fastest bomber, is to be completed and delivered to the Air Force this summer.

• **Douglas Aircraft Company, Inc. . . .** America's first jet transport for passenger service will be built by Douglas, the company announced in June. The swept-wing air liner is expected to have a top speed of 550 m.p.h. and to carry 80 to 125 passengers. Scheduled for its first test flight by December, 1957, the proposed DC-8 will be powered by an advanced version of the Pratt & Whitney J57 engine that is now in military use. . . .The DC-7B has been certificated for air-line use by the Civil Aeronautics Administration. This model, like the DC-7, has a top speed of 410 m.p.h., but the overseas version with extra tanks has an increased range of 5,120 miles. . . .A two-story, $500,000 office building will be constructed at the Santa Monica plant.

• **Elastic Stop Nut Corporation of America. . .**The ESNA Type 2424 self-locking, vibration-proof bushing has been designed for use in relatively soft castings, forgings, and extrusions such as aluminum alloy, magnesium, mild steel, and some plastics. The new bushing provides a self-locking blind fastening which adds to the strength and prevents wear and destruction of tapped holes in machined parts.

• **Fairchild Camera and Instrument Corporation. . .**Leon T. Eliel, President of Fairchild Aerial Surveys, Inc., has been elected to the Board of Directors.

• **Firestone Tire & Rubber Company. . .** Claiming to be the world's largest producer of rubber, the company announced it was producing more than 1,000,000 lbs. per day at its rubber plantations in Liberia and two synthetic rubber plants purchased recently from the federal Government.

• **General Electric Company. . .**The J47 is the first American aircraft jet engine to be licensed to a European manufacturer. The Fiat Works of Turin, Italy, has been licensed to build the J47-GE-27 and the J47-GE-33, which are used in the North American F-86F and F-86D, respectively. More than 34,000 J47 engines have been produced in the United States for military planes, G-E says. . . .European sales of aircraft accessories manufactured in the U. S. are rising at a substantial rate, according to G-E. . . .General Electric has announced

Air Forces give McDonnell's new debutante a big rush!

TEMCO HELPS PRODUCE POPULAR F-101 VOODOO

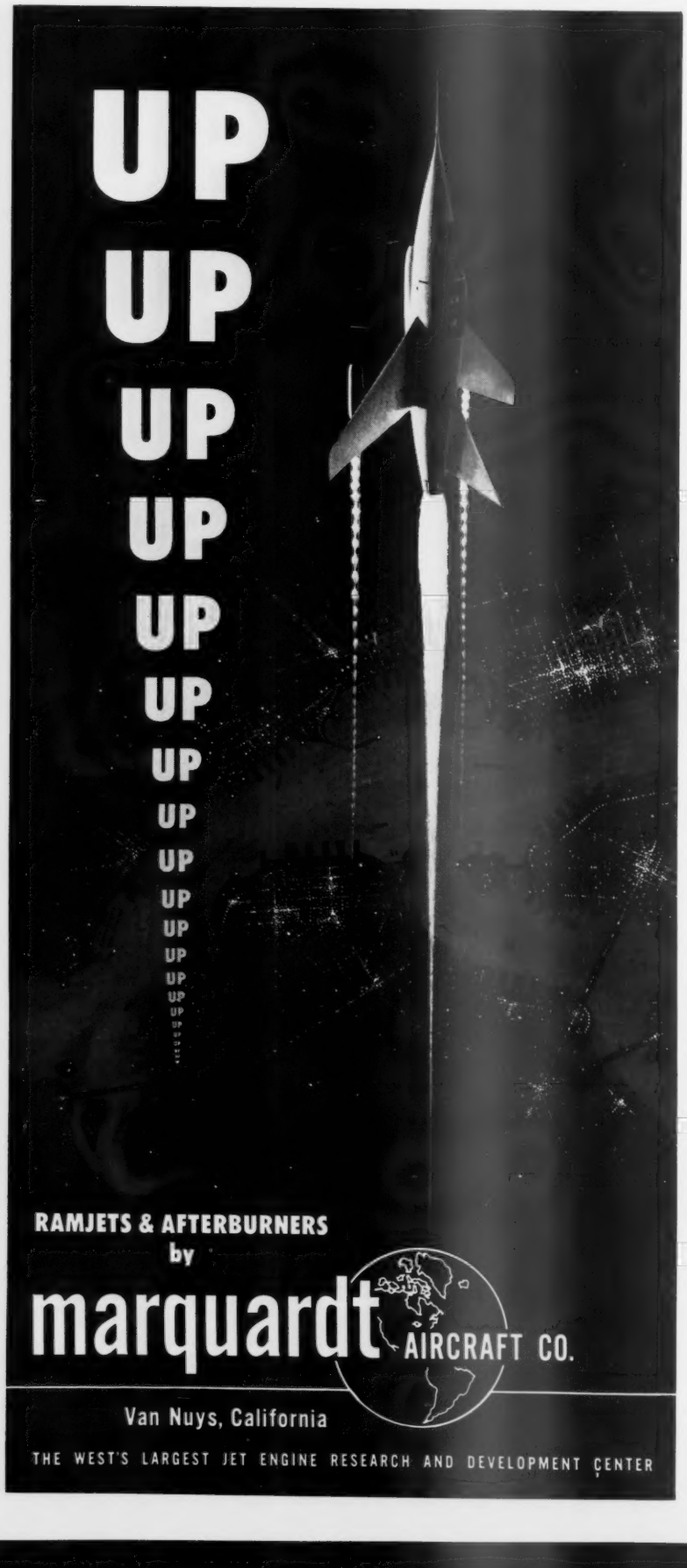
When the F-101 made her first public bow, she was already a much sought after plane. Designed as a long-range fighter, the *Voodoo* will first be assigned to the Strategic Air Command to escort our jet bombers. But interceptor and tactical air groups also are casting covetous looks at this big new jet. Reportedly the most powerful fighter in the world capable of cruising at well over the speed of sound for hours, she is wanted for defense against bombers and for use as a supersonic fighter-bomber.

To facilitate production of this important plane, TEMCO was called upon to fabricate aft fuselage sections. The award of this contract indicates the thoroughly satisfactory manner in which TEMCO has been handling work on another McDonnell fighter, the F3H *Demon*, and further establishes TEMCO's reputation for producing a quality product, on schedule, at the lowest possible cost.

Final assembly and inspection of aft fuselage section of F-101 prior to delivery to McDonnell.

ENGINEERS . . . If you are interested in a position with a *growing weapon systems organization*, write full particulars to E. J. Horton, Jr., Engineering Personnel, TEMCO Aircraft Corporation, P. O. Box 6191, Dallas 2, Texas.

TEMCO
AIRCRAFT CORPORATION
DALLAS, TEXAS



it will double the size of its microwave research laboratory at Stanford University because of rapid advances being made in the application of microwave electron tubes to the communications and radar industries.

• **The B. F. Goodrich Company.** . .Tubeless tires, which have been used on military planes for some time, are being tried experimentally by United Air Lines, Inc. They have been approved by the CAA for use on United's DC-6 commercial transports. . . .Goodrich, in association with Peruvian interests, is building a tire factory near Lima.

• **The Goodyear Tire & Rubber Company, Inc.** . . .A $3,000,000 Engineering and Research Building is under construction at the Goodyear Aircraft Corporation plant in Akron, Ohio. The three-story building will be air-conditioned and equipped with the latest instruments and facilities for research and for development of new products in the fields of aerophysics and electronics.

• **Kollsman Instrument Corporation** . . . The first automatic sextant in the history of aerial navigation has been designed by Kollsman engineers. It automatically sights and tracks the sun during the day and the stars and planets at night. It continues to track a star during and after changes in course. Manual sighting is not necessary. The Kollsman Photoelectric Sextant, which is not yet in production has a photosensitive telescope which searches a patch of sky until it recognizes the star to be tracked. It can be installed in any part ot the airplane where it has an unobstructed view of the sky. The combination of automatic operation and remote control offers many advantages, particularly in high-speed long-range aircraft where limited space and cumbersome pressure suits make it difficult for the navigator to move about. . . .A new cabin pressure control system now in production will be used in the Douglas DC-7C air liner. It holds changes in cabin pressure below 300 ft. per min. regardless of the rate of climb or descent of the airplane.

• **Lockheed Aircraft Corporation.** . .The Georgia Division is cooperating with Georgia Institute of Technology in a $75,000 program to modernize the 9-ft. wind tunnel at the Daniel Guggenheim School of Aeronautics. Carl F. Friend, MIAS, Division Engineer—Aerodynamics, is representing Lockheed, and other engineers will be assigned by the company to work with the Georgia Tech staff. After the wind tunnel is reopened next January, Lockheed will use it to evaluate wing shapes, fuselages, nacelles, and control surfaces, and for other aerodynamic research.

• **Loewy Construction Company, Inc., Subsidiary of Hydropress, Inc.** . . .An 8,000-ton extrusion press designed and built by Loewy-Hydropress will be installed this fall in the Torrance, Calif. plant of Harvey Machine Company, Inc. Forty flat cars were required to ship the disassembled press to the West Coast from Rochester, N. Y., where it was manufactured. Harvey Aluminum Division will operate the big press under the Air Force Heavy Press Program.

• **The Glenn L. Martin Company. . .**Earl R. Uhlig has been elected Vice-President—Finance. He continues as Controller.

• **Minneapolis-Honeywell Regulator Company. . .**The Aeronautical Division announces development of a lightweight, rugged, and accurate vertical gyroscope suitable for many autopilot, missile, and platform stabilization applications where caging is not required. The two-axis vertical reference instrument was designed to replace earlier noncaging types.

• **North American Aviation, Inc. . . .**Gerald B. Brophy, AMIAS, and Chauncey Starr have been elected Vice-Presidents. Mr. Brophy is the company's General Counsel, and Mr. Starr directs the Nuclear Engineering and Manufacturing Division. . . . The F-86K Sabre Jet is being manufactured in Italy by Fiat for NATO countries approved by the U.S. Government.

• **Northrop Aircraft, Inc. . . .**John R. Alison has been named Vice-President in Charge of Customer Relations and Robert R. Miller succeeds him as Administrative Vice-President. . . .Northrop is building a new version of the twin-jet Scorpion all-weather interceptor for the Air Force. The new fighter is called the F-89H.

• **Pan American World Airways, Inc. . . .** After testing airborne radar for 2,000 flying hours in its overseas transports, Pan American has decided to equip its entire fleet of DC-6's and DC-7's with C-band radar. This will make possible the observation of storm clouds up to 150 miles ahead and mountains, rivers and other terrain features 30 miles away. . . .Under an agreement with the Foreign Operations Administration and the Turkish Government, Pan American will send a team of 24 technicians overseas to train employees of the Turkish State Airlines in all phases of air-line operation.

• **The Parker Appliance Company. . .**Al Xander Company, Corry, Pa., has been appointed distributor of Parker O-rings for nearby sections of Pennsylvania, Ohio, and New York.

• **Pesco Products Division of Borg-Warner Corporation. . .**A new line of axial-flow blowers of advanced design is in production in a number of standard sizes at rated capacities from 16 cfm to 750 cfm. Each blower is a self-contained unit incorporating a rotor coupled to a Pesco electric motor, either d.c. or a.c., for precise control of air volumes. Manufactured under license from Plannair, Limited, of England, the blowers have been thoroughly proved by use in the British aircraft industry and have a wide variety of air, sea, and ground applications. Pesco suggests the following airborne applications: For cooling radio, radar, and electronic equipment; heating and ventilating cabins and cockpits; demisting and defrosting windows; cooling engine oil on helicopters; heating bomb bays and freight compartments; recirculating air in passenger transports; and spot heating or cooling uses.

• **Republic Aviation Corporation. . .**Republic has spent $125,000 on three runway crash barriers designed to stop an F-84 which runs out of runway in an emergency landing or an aborted take-off. The long net of nylon, canvas, and steel cable normally lies flat across the runway, but can

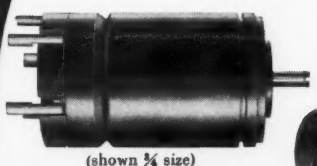
There is no one "cure all" for system instability. The desired stability of a servo loop is attained through the proper selection of components that satisfy the various conditions under which the loop will operate. Kearfott offers four basic motors and combinations for providing system stability. All feature high speed of response; low inertia and high stall torque.

SYSTEM STABILITY

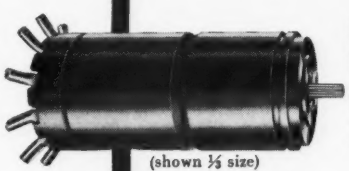
SERVO MOTORS: Servo motors with high torque to inertia characteristics possessing (built-in) inherent damping ranging in size from ¾" to 1¾" diameter are available. Low speed, low power motors for use in simple instrument servos where high damping and/or low time constant is required can also be provided.

VISCOUS DAMPED SERVO MOTORS: Provide integral viscous damping for simple instrument servos. Any degree of damping can be provided. These units reduce no load speed of standard motors to 50% or 75% of normal, providing 70% or 50% of critical damping respectively.

(shown ⅔ size)


(shown ¾ size)

(shown approximately ½ size)


(shown ⅓ size)

INERTIAL DAMPED MOTORS: Integral inertially damped motors for use in high speed and/or high gain servo systems—damping on acceleration or deceleration basis with little loss in normal no load speed. These units make possible system cut off frequencies up to 25 cps using magnetic amplifiers.

SERVO MOTOR TACHOMETER GENERATORS: For system stabilization by voltage feedback from an integral tachometer generator. May be obtained as damping generators for use in simple rate servos or as rate damping generators for use in very high gain systems. The latter feature high linearity, high output and maximum output to fundamental null ratios.

These servo motors are suitable for most exacting requirements. Write today for descriptive bulletin giving data of components of interest to you.

KEARFOTT COMPONENTS INCLUDE:

Gyros, Servo Motors, Synchros, Servo and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Aircraft Navigational Systems, and other high accuracy mechanical, electrical and electronic components.

Kearfott

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.

Sales and Engineering Offices: 1378 Main Avenue, Clifton, N. J.
Midwest Office: 188 W. Randolph Street, Chicago, Ill. South Central Office: 6115 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

be raised by remote electrical control by the tower operator. Major Gen. Samuel R. Brentnall, USAF, is credited with inventing the crash barrier in 1952 after 27 combat planes in Korea had crashed on take-off or landing. . . .During the past 10 years, Republic's test pilots have made more than 120,000 take-offs and landings and have flown 50,000 hours without damage to the person or property of any neighbor, the company said. . . .Republic announced it will develop the RF-105, a photo-reconnaissance version of the F-105 fighter-bomber, for the Air Force.

• **Ryan Aeronautical Company.** . .The Air Proving Ground Command will conduct an operational suitability testing program of the Ryan Q-2A Firebee drone missile this summer at Holloman Air Force Base, N.M. According to Ryan, the Air Force later plans to operate two squadrons of Firebees in the Air Defense Command training program at Yuma, Ariz. The guided missiles fly 600 m.p.h. and can be maneuvered by remote control up to 40,000 ft. to sharpen the aim of pilots, gunners, and anti-aircraft and guided-missile crews.

• **Shell Oil Company.** . .Shell Companies Foundation, Inc., has announced it will make nearly $350,000 available during 1955 to 39 institutions of higher education for fellowships, research grants, training of scientists, and other uses in advancing scientific knowledge.

• **Union Carbide and Carbon Corporation.** . .Howard S. Bunn has been elected Executive Vice-President and a Member of the Executive Committee. He formerly was a Vice-President and Director.

• **United Air Lines, Inc.** . . .United conducts the largest program of advanced flight crew training ever undertaken by an air line, the company claims. Four Curtiss-Wright Dehmel electronic flight simulators are now in use at flight training centers in Denver and Chicago, and when three more are delivered next spring United will have more simulators than any other air line, it claims. Two of the new ones will "fly" like a DC-6B, the third like a Convair 340.

• **Westinghouse Electric Corporation.** . .A skyway traffic light that directs departing planes toward a more sparsely settled take-off route has been installed near LaGuardia Airport to minimize air travel and noise over heavily populated areas. Tilted toward the airport, the pencil-thin beam rises from one of the most powerful searchlights ever built. It has a 2,500-watt short-arc mercury lamp developed by Westinghouse. The light is of approximately 300-million-beam c.p., equivalent in intensity to about 10,000 automobile headlights. The lamp is mounted in a 60-in. Army searchlight.

IAS Sections

Atlanta Section

Edith Hall Lively, *Secretary*

The April 13 meeting was observed as President's Night, with Robert E. Gross, President of the IAS, as guest speaker at a dinner given in the Atlanta Athletic Club. S. Paul Johnston, Director of the IAS, and Thomas J. Meskel, Assistant Secretary, came from New York for the occasion. The officers of the Georgia Tech Student Branch were guests, too, being represented at the speakers' table by their Chairman, G. M. Gray. E. I. Bricker, Chairman of the Atlanta Section, presided.

Following the dinner, Chairman Bricker reminded the gathering of over 200 that the Atlanta Section was organized just 3 years ago with approximately 25 members and now numbers more than 100. After presenting the guests of honor to the audience, he remarked that one attribute of an engineer should be his ability to select the best material for a particular job, and so he felt it eminently suitable to ask Dan Haughton, Vice-President of Lockheed's Georgia Division, to introduce the Guest-of-the-Occasion, Robert E. Gross, who is President of Lockheed Aircraft Corporation.

Mr. Haughton told of Mr. Gross's longtime interest in aircraft, from the time he learned to fly until he became involved in the industrial side, finally gathering a group of associates and acquiring the Lockheed Aircraft Corporation, which he so capably heads. Then he referred to the honor conferred upon Mr. Gross in January, when he was installed as President of the IAS.

Mr. Gross, though not an engineer himself, delivered a most provocative and thought-inducing message aimed at the creation of new techniques for increasing aeronautical advances by the engineers and of further discoveries and inventions by the scientists.

Referring to the tremendous changes that have taken place in the aircraft industry in the last 30 years, he stated that engineering developments accounted for a large part. The organization of the industry also is undergoing great change. Initially, only a handful of companies were in the aeronautical and automotive field, and they did 80 to 90 per cent of the work entailed in their own plants. Changes have come as an aftermath of World War II, the Korean War, new scientific concepts, and the acceptance of the fact that the problem of defense will be paramount for a long time. There has been a revolution in power units, engines, and flight patterns.

With the weapons system concept, Mr. Gross said, the aircraft companies ceased to be mere builders of aircraft frames and moved into the aviation business as a whole. All this requires highly skilled technicians, engineers, and scientists; hence many new faces have appeared in the industry. Out of 22 companies with system stature, only nine are aeronautical companies, seven deal with electronics, two are universities, and the remaining four are automotive. Among these varied industrial concerns are General Mills; U. S. Shoes; Bing Crosby, Inc.; Otis Elevator Company; White Dental Laboratories; and Minnesota Mining and Manufacturing Company.

Twenty-five years ago, said Mr. Gross, our nation's foreign policy had relatively small effect on national industry. Today, the new foreign policy of the United States has become the dominant factor, with aircraft one cor-

At the speakers' table at President's Night Dinner of the Atlanta Section were *(left to right)* Arnold L. Ducoffe, IAS President Robert E. Gross, E. I. Bricker, Dan T. Haughton, Edith H. Lively, Thomas J. Meskel, and E. S. Williams. Also present were S. Paul Johnston and G. M. Gray, who were outside camera range.

A new kind of airplane makes the news

. . . with a new kind of power transmission designed and built by FOOTE BROS.

A revolutionary aircraft, McDonnell's XV-1 Convertiplane, recently made news by completing the first successful conversion from vertical to horizontal flight . . . a *totally new concept of flight* which combines the vertical flight characteristics of a helicopter with the speed and range of a conventional fixed wing aircraft.

To help put this remarkable aircraft in the air required a completely *new kind of power transmission* for the pusher propeller and the rotor which is driven by pressure jets located at the tip of each of the three blades. McDonnell called on Foote Bros. to design and build this highly intricate transmission. The successful flight of the XV-1 is ample testimony to the skill and capacity of Foote Bros. to meet the exacting needs of America's great aircraft manufacturers. It will pay *you* to see Foote Bros. first—the right place to bring your power transmission and mechanical actuator problems!

FOOTE BROS.

Better Power Transmission Through Better Gears

Since 1859

Foote Bros. Gear and Machine Corporation
4545 South Western Boulevard
Dept. G, Chicago, Illinois

FOOTE BROS. Duti-Rated LIFETIME GEARING

This trademark stands for the finest industrial gearing made!

T.M. REG. U.S. PAT. OFF.

Bendix Red Bank

ECLIPSE

TYPE 30E16 DC GENERATOR

With its 30-volt, 100-ampere rating, the Type 30E16 offers increased output and reliability that make it the ideal replacement for existing 50 and 75 ampere aircraft generators. In most cases, it can be used with existing control equipment—with types 1042-17 and 1589-1 voltage regulators, for example.

This generator can be furnished with either square or round mounting flange and is suitable for use on Continental R9A, P & W 985, P & W 1340, P & W 1830 and Wright GR 1820 engines.

For military applications, the generator conforms to AF Drawing 52B-6588 and will deliver full output at 35,000 feet altitude and 75% rated power at 50,000 feet.

CHARACTERISTICS

Speed	2500-4500 rpm
Min. Speed for Regulation	2500 rpm
Max. Speed for Regulation	5500 rpm
Power	3000 watts
Min. Air Blast Pressure	6 in. water
Weight	39.5 lbs.

For complete information about Bendix Red Bank Generators . . . both DC and AC . . . write us today.

Bendix Red Bank

EATONTOWN, N. J.

DIVISION OF Bendix AVIATION CORPORATION

West Coast Sales and Service: 117 E. Providencia Ave., Burbank, Calif.
Canadian Distributors: Aviation Electric Ltd., P.O. Box 6102, Montreal, P.Q.
Export Sales: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.

nerstone and the atom another. Our international position can improve or go down, and so also can the aircraft industry. Defense has become a permanent part of our lives and has come to be regarded throughout the industry as more of a peace project than a war business.

Aerial weapons may become the product of ordnance or arsenals or of some universal jack-of-all-trades companies, or they can be developed alongside the carrier field and stay with the aeronautical companies. Mr. Gross hopes the latter may be the ultimate outcome. In order to do so, aircraft companies should share their knowledge with other companies, broaden out, and use each other wisely for their mutual good. The nine and one-half billion appropriation for military weapons for 1955 may well grow to eleven or twelve billion in a few years.

The air carrier field, however, is a solid place for the aeronautical industry and can be planned for in advance. Those in the industry should take charge of it, especially in view of the fact that every day adds 9,000 new potential air-riders.

How can the engineer help the company for which he works? Mr. Gross suggested ten phases toward which those in the industry should turn their talents for the next few years:

(1) The problem of drag reduction at supersonic speeds.

(2) Stress boundary-layer control.

(3) Attempt to reduce the effect of high-speed turbulence.

(4) Discovery of new and/or exotic fuels.

(5) Practicability of nuclear field, especially in shielding from radiation, or discovery of an atom bender.

(6) Invention of modes for individual flight; possibly a unit to be strapped on the back.

(7) Seek means of counteracting or neutralizing gravity.

(8) Increased use of mechanical computation so as to check passengers and their baggage in and out more quickly.

(9) Further inventions of computing systems to give faster answers on more variable bases for use in preliminary design.

(10) Change in the attitude and frame of mind of the engineer himself so that specializing in the field of aeronautics does not cause him to lose his perspective of, and knowledge in, the whole field of the arts and the humanities.

Mr. Gross summed up his thinking by stating that a more fundamental attitude is needed throughout industry, with more emphasis on processes and less on the mere mechanics. Above all, the spiritual mind should not be lost in materialism.

Baltimore Section

Raymond D. Blakeslee, *Secretary*

Forty members and guests attended the May 12 meeting held in Maryland Hall, The Johns Hopkins University.

After a business session at which nominations of officers for 1955–1956 were presented, Chairman Herman Pusin introduced William Street, Chairman of the Program Committee. Mr. Street then presented the speaker of the evening, Capt. Norman Lee Barr, USN (MC), Head, Operational Programs Division and Aviation Medicine Division, Naval Research Institute, Bethesda, Md.

Captain Barr spoke on the subject, "Recent Advances in Aviation Medicine." His talk is summarized under the following primary topics:

Mission of Aviation Medicine Division: Study the aviator in his environment. Determine the extent of the forces acting upon him, and develop instruments and techniques to increase his tolerance to these forces.

(1) *The Aviator*—Radio Transmission of Physiological Data for Air-to-Ground: It is of prime importance that knowledge of the physiological functioning of the aviator be obtained as the aviator is under actual flight conditions. As a means of accomplishing this, recent work has been directed toward developing miniature amplifier and transmitter systems that will allow measurements of such important features as heart action, brain waves, pulse rate, respiratory rate, and volume and body temperature to be telemetered to recording and display systems on the ground. This allows an immediate analysis of changes occurring in bodily functions as the aviator experiences the varying forces acting on him in high-speed, high-altitude flight.

(2) *The Environment*—Visibility Research: One of the aviator's primary means of adjusting to the constantly changing flight situations is by visual reference to external features of his environment. In matters of target detection and in the routine operations of landing, problems of visibility become of paramount importance. To expedite research in these matters, a large body of basic data on the brightness of the sky and terrain has been gathered. Through use of these data, theoretical systems for the specification of the limiting distances at which various types of aircraft are visible have been derived. Systems that will furnish immediate information on the visibility of various airport runways under all types of weather conditions also have been designed. The field testing of both is planned in the immediate future.

(3) *The Aviator as a Functional Part of His Environment*—

(a) Research on Relation Between Pilot Performance and Sympathetic Nervous System Activity: This study was designed to investigate a pilot's "emotional" activity, as measured by the galvanic skin response, and to determine its relation to his performance. Measures of G.S.R. were taken during actual flight operations. Pilots flew prescribed maneuvers, part of which were accomplished under simulated instrument conditions. When, under such conditions, all visual terrain reference was removed and all attitude instruments were taken from the panel, it was found that performance was poorer and G.S.R. activity greater during the "partial panel" or instrument conditions. For the various pilots, correlations between G.R.S. and performance seemed to be either consistently positive or consistently negative, indicating that the effects of emotional activity may be either facilitative or disruptive.

(b) Flight Safety Research: In an earlier study, a comprehensive list of observable acts of unsafe pilot behavior was gathered. These acts were validated as having been listed as causative factors in Navy accident records. In recent research, selected items from this list were used in shipboard testing of pilots conducted to evaluate the relative safety of the members of a carrier air group.

Subjects for this study were 90 pilots aboard a Navy aircraft carrier undergoing operational exercises in the Mediterranean. These pilots evaluated, by means of peer ratings, the other members of their squadron both as to safeness and skill. In addition, measures were taken of the pilots' attitudes toward certain features of flying, their subjective evaluations of the importance of the above safety items, and their "emotional" responses to these same safety items.

The major finding was that a different set of test procedures must be used in detecting "accident proneness" in low-ranking and in high-ranking officers. It was also found that attitudes toward flying are related to a pilot's safeness. For ensigns, the safest pilots consistently overestimated the importance of safety procedures. For senior officers, the less safe pilots showed more G.S.R., or "emotional" activity, when viewing the items of flight safety procedure.

Boston Section

John B. Tucker, *Secretary*

The annual spring dinner meeting was held at the Thompson Club in Nahant on May 31. The meeting started with a social hour sponsored by the Aircraft Accessory Turbine and Small Aircraft Engine Departments of the General Electric Company.

Following a chicken dinner, there was a brief business meeting at which the election of officers for the coming year was announced: Robert L. Halfman, Chairman; Edward L. Dashefsky, Vice-Chairman; Walter McKay, Secretary; and John B. Tucker, Treasurer.

Chairman Joseph J. Jerger then introduced the guest speaker of the evening, Jerome C. Hunsaker, Chairman of the National Advisory Committee for Aeronautics and retired head of the Aeronautical and Mechanical Engineering Departments at Massachusetts Institute of Technology. The Langley Gold Medal was recently presented to Mr. Hunsaker by the Smithsonian Institution. This announcement aroused considerable interest among his younger associates, who were not familiar with this award for the obvious reason that it had not been presented in 20 years. Mr. Hunsaker is the ninth recipient of this coveted honor.

Mr. Hunsaker spoke about the continual battle between stability and control in airplane design. If an airplane is designed to be exceedingly stable, then it is very slow in control and extremely unmaneuverable. On the other hand, if it is extremely unstable, it is a continuous battle for the pilot to fly the airplane. Therefore, a reasonable compromise makes the airplane very maneuverable and reasonably easy to fly. Mr. Hunsaker went on to say that all of the rules of stability for subsonic aircraft were now being violated in supersonic flight. What had previously stabilized airplanes in the past could no longer be counted upon as a "fix" for supersonic planes. The placing of the heavy engine in the tail of the aircraft and the counterbalancing of this weight by a longer forward fuselage, plus the use of sweptback wings that approach the tail, present extremely difficult stability problems to the fuselage designer.

Mr. Hunsaker expressed the opinion that the airplane should be inherently stable and that a minimum of gadgets should be employed for stability—and only when absolutely necessary. He pointed out that, if there are 17 gadgets required for stability, there is a good chance that on 17 successive days one or another of these gadgets might not function. Hence, the pilot could find himself continuously in a position of fighting the airplane to maintain stable flight. It was pointed out here that this belief was not necessarily true when applied to pilotless aircraft, but, when completely automatic controls were available, the basically unstable missile could easily be stabilized.

Chicago Section

Leland W. Sims, *Secretary*

On June 1 the annual business meeting was held at the Glenview Naval Air

HYCO-SPAN control cables SAVE 90 POUNDS

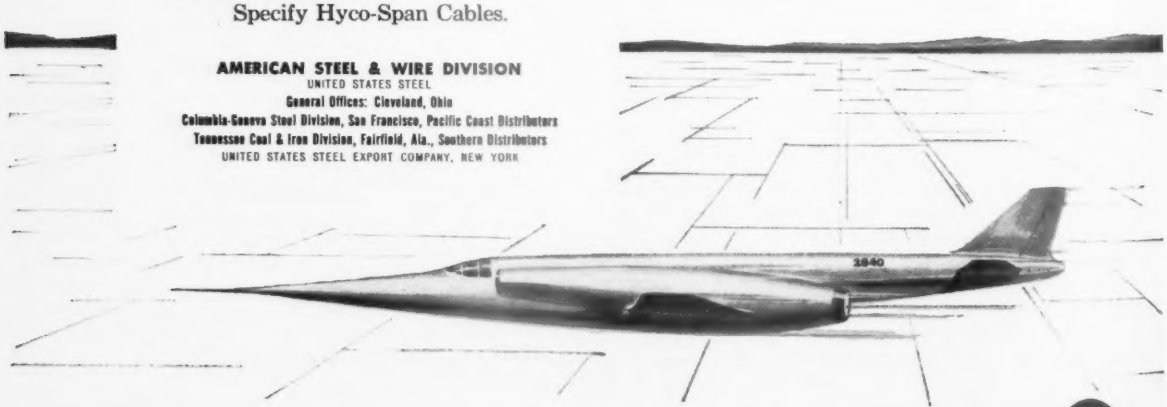
Hyco-Span Control Cables expand and contract at nearly the same rate as aluminum alloy air frames. So they stay tight at high altitude and low temperature . . don't get too tight when temperature soars.

As a result, you can eliminate as much as 90 pounds of useless dead weight by simplifying control cable installations.

Also: Hyco-Span Cables resist corrosion as well as stainless steel . . . operate safely on low cable tension . . . seldom require readjustment . . . are non-magnetic . . . do not affect the accuracy of sensitive instruments.

Specify Hyco-Span Cables.

AMERICAN STEEL & WIRE DIVISION
UNITED STATES STEEL
General Offices: Cleveland, Ohio
Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors
UNITED STATES STEEL EXPORT COMPANY, NEW YORK



USS American HYCO-SPAN Aircraft Control Cables

Station. At 5:30 p.m. buses carried members and guests to the main hangar of the Air Station where an exhibit had been prepared by the Training Department under the direction of Commander Barry. Current Navy aircraft used for training and combat, as well as jet-engine and armament systems, were on display.

At 7:30 p.m. dinner was served to 120 members and guests. This was followed by the business meeting, which was opened by Chairman Richard A. Schram. Mr. Schram introduced Harold V. Hawkins, the Chairman of the Nominating Committee, who read the proposed slate of officers and Advisory Board for the year 1955–1956. Since no further nominations had been received by the Secretary prior to the meeting, the slate of candidates was unanimously elected by the members present.

The officers elected for next year are as follows: J. W. Pocock, Chairman; B. M. Vinicky, Vice-Chairman; H. A. Wiant, Secretary; H. W. Warzyn, Treasurer. The Advisory Board Members are: R. O. Britton, K. L. Burroughs, H. V. Hawkins, T. C. Linnert, R. A. Schram, L. W. Sims, Lt. Col. D. J. Smith, and A. F. Stott. The Representative to the Nominating Committee for Area Councilors is C. F. Eck.

Mr. Schram introduced Mr. Pocock, the Chairman-Elect, who has been Vice-Chairman of the Section and Chairman of the Program Committee. The meeting closed with the showing of *Naval Aviation*, a film that showed the Navy in action in various combat areas and traced the development of Naval aviation.

Columbus Section

P. V. Titus, *Secretary*

New officers for 1955–1956 were installed at the May 24 meeting: Chairman, John D. Lee; Vice-Chairman, Rudolph L. Tank; Secretary, James T. Overbey; Treasurer, Frederick J. Clemens; Members of the Executive Board, Alpha G. Winnett, Jr., and F. A. Wedberg.

Dayton Section

Gunther R. Graetzer, *Secretary*

The final meeting of the season was held May 26 at Cordell's Supper Club. Forty-nine members and guests attended the business session and dinner, and many more came for the technical discussion.

Chairman George McTigue announced the election of the following officers for 1955–1956: W. D. Dodd, Chairman; G. R. Graetzer, Vice-Chairman; T. J. Keating, Secretary; W. E. Stanger, Treasurer; G. J. McTigue, Representative to the Nominating Committee for Area Councilors; D. G. Samaras, Capt. R. E. Hale, E. Wheeler, and F. E. Carroll, Jr., Council members.

The technical discussion featured Dr. Neil R. Burch, Capt., USAF, as speaker on "Pilot Stress and Fatigue." Dr. Burch, an Air Force psychiatrist who has been working with the Aero-Medical Laboratory at Wright-Patterson Air Force Base for many years, discussed the concept of the human as a series of negative feedback networks, the measurement of the nervous system, fatigue tests, and practical applications to the man-machine weapons system. Some highlights of the unusually interesting talk are given here.

Irritability or responsiveness to a stimulus is the prime characteristic of living tissue. The human brain shows this characteristic to the highest degree. An evoked response in surgically isolated brain tissue tends to spread both in time and space throughout associated cells. This tendency for neurophysiological spread, or "prolixus," would clearly lead to an unstable state in the intact brain if some control mechanism, such as negative feedback, were not introduced.

A particular function of an older structure in the brainstem is "arousal" or "alerting" of the cortex, a process related to a decrease in prolixus. Conversely, relative depression of the brainstem allows increased diffusion of an evoked disturbance in the cortex. Negative feedback arises when the brainstem is stimulated by the same signals that feed into and stimulate the cortex. Correspondence between prolixus and "psychological diffusion" predicts that psychological diffusion would decrease with stress and increase with fatigue. Indeed, the psychiatrist speaks of "constriction of integrative span" with stress, and the psychologist points to fatigue as a "progressive widening of the field from which selection is made and consequent loss of direction."

Direct measurements in the brainstem of animals show increased electrical activity under drug-induced stress. Direct measurements in human brains are not feasible and force the use and development of indirect techniques such as sweat response and brain-wave response. The change in these responses to a standardized stimulus or "jolt" indicates the "inertia" of the nervous system. Increased inertia with progressive fatigue conditions can be demonstrated in simulated pilot situations.

Objective measurements of the stress or fatigue imposed on a man by a machine should allow better design of the total man-machine complex.

Hagerstown Section

Andrew Pickens, *Secretary-Treasurer*

The monthly meeting was held at the Terrace Restaurant May 17, with Vice-Chairman R. E. Eisiminger presiding.

C. L. Chumley introduced the evening's speakers—E. R. Gelvin, Supervisor of Flight Test; D. W. Weller, Chief of Flight Test Engineering; W. O. Hammer, Assistant Manager of Customer Relations; and W. F. Mumma, General Supervisor of Service Publications, all of the Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation.

Mr. Gelvin described the organization of the Flight Test Department, the operation of company-owned planes, and the processing of new production aircraft. Mr. Weller discussed the nature of engineering flight-test work and the ways in which a flight-test program may be initiated. Two motion pictures were presented. One showed YC-123B tests simulating main-engine failure during very-high-gross-weight take-offs with jet assist; the other explained the concept of the C-123B "Flying Lighter."

During a break in the program, H. C. Billings, Chairman of the Nominating Committee, presented and received approval of the list of candidates for the coming election of officers.

The remainder of the program was devoted to the Customer Relations Department, with emphasis on the preparation of technical publications. Mr. Hammer outlined the responsibilities of the department in relation to technical publications. With the aid of an elaborate set of charts, Mr. Mumma gave a detailed description of the work of the Service Publications Department. During the refreshment period the members examined a display of technical publications and flight-test instrumentation.

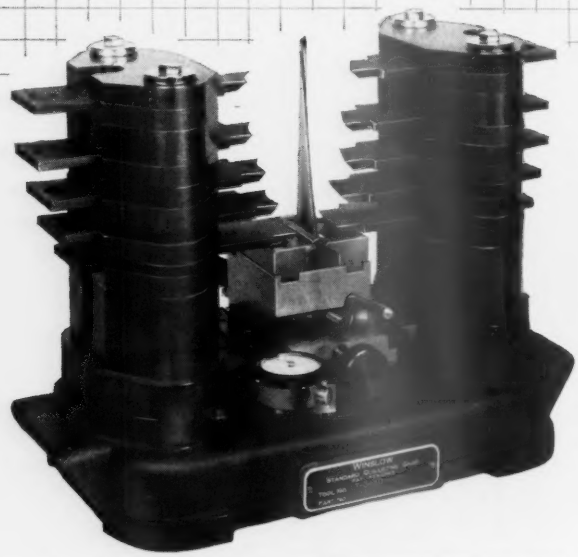
Hampton Roads Section

William D. McCauley
Recording Secretary

Fifty members of the Hampton Roads Section were given a conducted tour of the U.S.S. "Forrestal" by the Newport News Shipbuilding and Dry Dock Company on Saturday morning, May 28. The occasion was a joint meeting of the engineering societies of the Virginia Peninsula. Also attending the tour were members of the Propeller Club of the United States—Port of Newport News, Society of Naval Architects and Marine Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, The American Helicopter Society, and the Engineers' Club of the Virginia Peninsula.

The "Forrestal" is 1,036 ft. long and 252 ft. wide at the deck—wider and longer than any other naval vessel

here it is! the perfect answer to precision airfoil inspection of jet engine blades!



THE WINSLOW STANDARD GUILLOTINE GAGE

- assembled from stock components
- interchangeable parts
- quick delivery
- checks all 10 features
- maintains original accuracy
- lower original cost
- less down-time
- quickly re-worked for parts changes

Already in use by the leaders of the jet engine industry, this new kind of guillotine gage solves the problem of maintaining accuracy. Templates are supported over a much larger area of their surface, making wear negligible. And alignment is guaranteed by heavy stacked towers that are bolted together for ruggedness and complete rigidity. Winslow's new design and assembly from precision-built interchangeable parts give six big advantages. You get quick delivery and lower original cost. You save on maintenance—in case of damage substitution of some parts can be made without even removing the gage from your inspection line.

Gage down-time is cut, requiring fewer gages and avoiding costly production holdups. And finally, you reduce your gage investment with a truly multi-purpose instrument—check all 10 features of a jet engine blade with a single gage; check forging and finished part with only one gage. No more gage obsolescence—Winslow's Re-Work Service quickly up-dates the gage when your part changes. Easy to use and easy to read, the Winslow speeds production, gives "more accuracy for less money."

Write for literature, get the full story on Winslow standard and special gages . . . for every precision control problem.

WINSLOW MANUFACTURING CO.
1755 EAST 23 STREET • CLEVELAND 14, OHIO

WINSLOW PRECISION ALWAYS

first name in precision control

afloat. Its speed would surprise the enemy and would be an important defensive feature, for the new supercarrier has the ability to outrun the enemy. An improved "torpedo defense system" would make it less vulnerable to attack by submarines. It has batteries of rapid-fire, 5-in. guns, coupled to an electronic fire control system to take care of enemy planes that manage to get through the defending fighter planes.

With its four steam catapults, the "Forrestal" will be able to launch airplanes faster than any other carrier. Several types of planes will be flown from the "Forrestal," including the Douglas A3D Skywarrior, the Douglas F4D Skyray, the North American FJ-4 Fury, and the Douglas AD-5 Skyraider. The "Forrestal's" jet planes would be able to strike targets far beyond the reach of earlier carrier-based aircraft.

▶ On the evening of May 28, about 85 members and guests attended a dinner dance in the ballroom of the Williamsburg Lodge, at Williamsburg, Va. After dinner, the latest motion picture produced by the National Advisory Committee for Aeronautics was introduced by Hartley A. Soulé, Assistant Director of Langley Aeronautical Laboratory. The movie showed the importance of research in aviation and gave an idea of the wide variety of research being conducted in the NACA laboratories. Besides proving enlightening to some of the members, the film gave the members' wives a better understanding of the work being done by their husbands.

Following the movie, there was dancing to music by the Johnson Combo. The enthusiastic response to the Section's first dinner dance is expected to lead to a similar affair next year.

Indianapolis Section

Paul F. Ferreira, Jr., *Secretary*

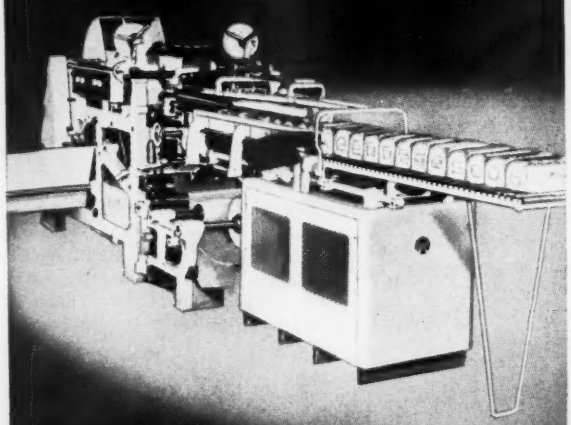
The final meeting of the season was held on May 24 at the Athenaeum Turners Club. Eighty-five members and guests enjoyed the social hour and a baked chicken dinner.

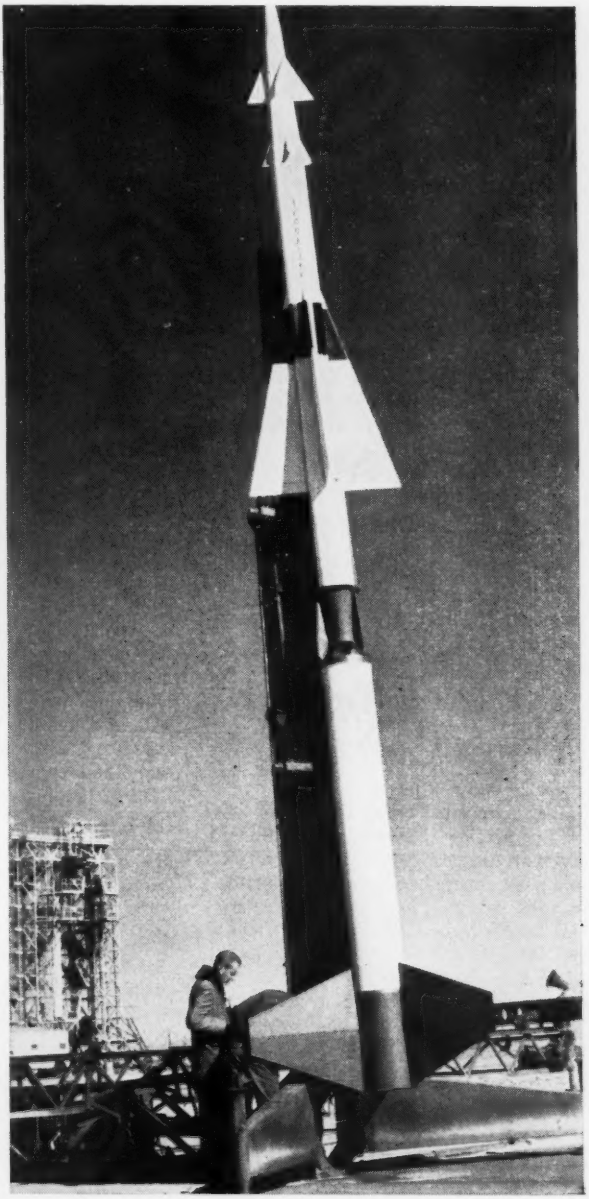
Chairman E. M. Howard opened the business meeting with a discussion of the Section's constitution and by-laws, which were adopted as presented by the Constitution Committee.

The following officers were elected for 1955–1956: Chairman, Philip N. Bright; Vice-Chairman, Maurice J. Zucrow; Secretary, George J. Clingman; Treasurer, Robert E. Saff; Board Members, Dimitrius Gerdan, Paul E. Stanley, and Allen R. Stokke.

John B. Wheatley, Meeting Chairman, introduced the speaker, J. W. Darley, who is Supervisor of Programming, Aircraft Nuclear Propulsion Department, Evendale Plant, General Electric Company. Mr. Darley used

From wrapping bread to launching missiles...





Designing and producing intricate bread-wrapping machinery, or developing guided-missile launching equipment... each demands advanced technology. And these are but two of the *hundreds* of complex tasks the AMF organization performs every day.

The highly specialized yet widely diversified activities of some 35 engineering and production facilities provide AMF with a wealth of experience that covers nearly every field of industry. And it is immediately available to *you*.

Call upon AMF with your problem. See why this all-around experience in answering the needs of government and industry has made AMF the "can do" company.

AMF HAS EXPERIENCE YOU CAN USE!

IN RESEARCH DEVELOPMENT PRODUCTION

ARMAMENT | BALLISTICS | RADAR | MISSILE GROUND EQUIPMENT | AUXILIARY POWER SUPPLIES | WEAPONS SYSTEMS

AMERICAN MACHINE & FOUNDRY COMPANY, Defense Products Group, 1101 N. Royal Street, Alexandria, Virginia
Executive Offices—AMF Building • 261 Madison Avenue, New York 16, N. Y.

two motion pictures to amplify his subject, "A Is for Atom." A color film of the same name presented basic information and explained what has to be done to harness the atom for nuclear propulsion. The second movie, *Atoms Go to Sea*, described the harnessing of the atom for marine propulsion as applied to the submarines "Sea Wolf" and "Nautilus."

Mr. Darley discussed the National Atomic Energy Program from its start with a $5,000 White House miscellaneous check by President Franklin D. Roosevelt to the present expenditure of $14,000,000,000, covering the following points: (1) materials for production; (2) development of power-producing reactors; (3) special purposes; (4) summary of applications, 1955—defense, electric power production, and isotopes; and (5) main technical problems.

Mr. Darley held the meeting open for 40 min. of lively discussion on the problems of shielding, control of atomic reactors, atom-powered aircraft, etc.

Los Angeles Section

Joseph W. Wechsler, *Secretary*

At the May 19 dinner meeting Heinz Haber, Associate Physicist, Department of Engineering, University of California, Los Angeles, spoke to 85 members and guests on "The Problem of Weightlessness in Present and Future Aviation." He was introduced by Dr. John R. Poppen, Consultant in Aviation Medicine, Douglas Aircraft Company, Inc., Santa Monica Division. Warren Dickinson, Section Chairman, presided at the meeting.

As a preliminary step in discussing the results of a situation of weightlessness, Mr. Haber brought his audience up to date on the definition of weight itself. Whereas Newton spoke of weight merely as the force of gravity on a body, modern scientists have had to frame a more general definition that accounts for inertia forces, as well as that of gravity. D'Alembert's principle, which states that the resultant of the gravitational, inertia, and external—i.e., deforming—forces on a body must equal zero, provides the key to this general definition of weight—namely, the negative of the sum of the external forces on a body.

Two techniques have been used in producing experimental conditions of weightlessness. One method—having the subject and the container (or vehicle) fall together—is practiced with high-altitude rockets. The other method, used with airplanes, is to fly the vehicle "around" the subject as the latter follows a trajectory determined by gravity and inertia forces alone. With current aircraft, however, this technique is limited to about 30 sec. of weightlessness.

Mr. Haber then discussed the most important anticipated effects of weightlessness—loss of orientation and loss of control over body movements. Each of these functions depends on the existence of at least two of a set of three modes of contact with external surroundings. The orientation "triad" consists of visual contact, the equilibrium mechanism of the ear, and physical touch with the surroundings. In a weightless condition, only visual contact remains, and therefore it is thought that orientation may be lost. Control of body movements depends upon the use of muscle power, the sense of touch, and the sense of posture (relative positions of the limbs). Only the last-named is retained during weightlessness, so that this function too may be lost. Both of these predictions have been borne out, as far as possible, by the limited experimentation carried out to date. Fortunately, however, this experimentation has also indicated that, through practice, a subject can regain control of these functions during weightless periods.

The speaker also related several anecdotes from his work with the Disney Studios in preparing the recent "Disneyland" television program on space travel. In this connection, he commended the service being rendered by Walt Disney in explaining the role of scientists and engineers in our society and in attracting young people to these fields. A showing of the 10-minute film strip on weightlessness from the television program concluded the formal presentation.

Donald Coles
Specialist Meetings Committee

At a specialist meeting held on May 24, A. M. O. Smith, Supervisor, Aerodynamic Research, Douglas-El Segundo, spoke to 45 members and guests on "Predicting Transition in Incompressible Flow."

After a brief review of the work of Dryden and others in correlating transition data, Mr. Smith described some recent calculations of laminar stability in the presence of pressure gradients. The calculations were based on the Tollmien-Schlichting theory of small disturbances, using Pretsch's approximate solutions for the one-parameter flows studied by Falkner and Skan. Assuming that the rate of amplification in an arbitrary pressure gradient is given locally when the Flakner-Skan parameter and the Reynolds Number based on displacement thickness are known from boundary-layer theory, the net amplification of the most critical frequency can be determined by a streamwise integration.

Morris Feigen
Specialist Meetings Committee

Warren E. Mathews, Head, Advanced Research Staff, Guided Missile Division, Hughes Aircraft Company, was the speaker at a specialist meeting held on May 10. The lecture, which was attended by 50 members and guests, was entitled "Analytical Prediction of Missile Guidance Accuracy."

The general analytical solution for the miss distance of a homing missile using only line-of-sight information for guidance was presented. The results were obtained directly from a linearized block diagram of the problem without calculation of any of the rest of the missile trajectory. The method involved determination (in closed form) of a characteristic response function for the varying-parameter linear feedback system. From this function, the response to arbitrary inputs can be found by the usual inverse Laplace transform procedure.

Harold R. Sweet
Field Trips Committee

Forty-five members of the Los Angeles Section toured the Pasadena Air Filter Center on May 3. The tour followed a movie depicting the operation of the Civil Defense Organization and an orientation talk during which general questions were answered. The Civil Defense Organization has the responsibility of detecting and identifying aircraft and relaying this information to the military, who in turn are charged with positive identification and/or interdiction and destruction. To this end, the Pasadena Air Filter Center serves as the connecting link between the civilian and military segments of the operation.

Niagara Frontier Section

Clifford L. Muzzey, *Secretary*

The annual business meeting was held May 11 at the Airways Hotel. This is one of the new facilities built recently in the vicinity of the Buffalo Municipal Airport, which is undergoing a considerable modernization program. The airport location appears promising for future section meetings.

The business session was opened by Chairman George Melrose, who called for reports by Secretary Cliff Muzzey and Treasurer Herb Lawrence. A proposed slate of officers for next year was recommended by the Nominating Committee, headed by Lester K. Fero.

At the conclusion of the business session, the meeting was turned over to Ben Hamlin, who introduced Bob Stanley, President of Stanley Aviation Corporation.

Freedom's Team

At outposts of freedom near the Arctic Circle–made possible by our agreements with other governments which stand with us against aggression – U.S. Air Force men are now standing around-the-clock, around-the-calendar guard. Backing them up are the resources of American science and industry which have produced the Northrop Scorpion F-89 all-weather interceptor. The F-89 is America's heaviest-armed fighter. Wing-tip "hornet's nests" which carry 104 rocket projectiles are coupled with the latest electronics to make the F-89 a deadly aerial destroyer, capable of striking a bomber 45,000 feet and more above the earth. These jet home defenders are one of many modern weapons created by the engineering and production complex of Northrop Aircraft, Inc., since 1939 America's first company in the vital design, development and production of all-weather and pilotless aircraft.

NORTHROP

NORTHROP AIRCRAFT, INC. • HAWTHORNE, CALIFORNIA

Pioneer Builders of All Weather and Pilotless Aircraft

Bob told us of his recent flying trip to the Antilles, the islands of the Caribbean. Adequate planning and a good airplane in good condition permitted Bob and his family to complete their trip without hair-raising aeronautical adventures. Suspense and action were provided by skin diving and spear fishing in the tropical waters of the islands. Bob's enjoyable talk, which attracted an audience of about 70, was supplemented by color movies of the area.

San Diego Section

James G. Wenzel
Chairman

The student aid activity of the Institute of the Aeronautical Sciences has been designated one of its most important fields of endeavor. The San Diego Section, with H. Tracy Brooks as Student Aid Committee Chairman, has launched an aggressive program directed toward students in all age groups.

On the college level, efforts have been concentrated on San Diego State College. Vocational guidance speakers have been supplied and guidance manuals distributed to incoming freshmen. A Student Branch of the Institute was formed, which, under the guidance of Charles Morgan, Assistant Professor of Engineering, has been rapidly increasing in both membership and activities. The Student Branch is assisted by the Student Aid Committee in obtaining interesting speakers, scheduling field trips and general counseling.

In order to encourage the selection of engineering as a vocation, much of the Committee's activity has been directed toward students in the high school and prehigh school age bracket.

James G. Wenzel *(left)*, Chairman of the San Diego Section, and E. W. Robischon *(right)*, IAS Western Region Manager, congratulate winners in the 1955 Science Fair conducted in San Diego schools. The high school seniors are Evelyn LaHeist and David Smith, who both won a trip to the National Science Fair in Cleveland. Miss LaHeist's exhibit on "Protozoa" later took the national second prize in the senior division.

Nearly every high school in the metropolitan area was visited by a representative of the Institute during "Career Days." This program is carried out in cooperation with the San Diego Engineer's Council and consists primarily of panel discussions on the field of engineering.

Considerable support was given to the San Diego "Science Fair" held April 15–19 in the Institute's building in San Diego. The Fair was conducted by the city schools and received support of nearly all the educational and industrial groups in the city. Some 50 exhibits of scientific projects developed and built by junior and senior high school students in San Diego's public, private, and parochial schools were on display. The students were competing for various honors, including the grand prize of an all-expense-paid trip to the National Science Fair held in Cleveland. Two such trips were given.

The use of the Institute building was donated by the San Diego Section. During the months preceding the Fair, counseling service on problems encountered in engineering projects was offered. An exhibit centered around aluminum as a raw material provided by science was supplied by the Student Aid Committee. E. W. Robischon, Western Region Director of the IAS, was available for student counseling service for the duration of the Fair.

The most recent project of the committee was the production of a half-hour television program, entitled "What Makes an Airplane Fly?", presented on San Diego's KFMB-TV on May 17. The program was produced in cooperation with the city schools' visual education program and was viewed in classrooms of grades four through nine throughout the city, in addition to the normal television audience.

Explanations were given of lift, drag, thrust, and control with the aid of charts, models, and film strips. The basic purpose of the program was to help encourage the interest of young

Dwight H. Bennett, AFIAS, Convair's Chief of Aerodynamics, explains lift and drag to John Gute and Jane Cook, two grammar school pupils who took part in the television program conducted by the San Diego City schools with assistance from the IAS San Diego Section.

SHAFER
AIRCRAFT BEARINGS
ON TODAY'S PLANS.
TOMORROW'S SKIES
ConCaVex Design
...10° plus or minus self-alignment always available
...Easy relubrication without disassembly
...High radial and full thrust load capacity
...Exceptional shock-load reserve strength
LEADING BEARING DESIGN FOR MORE THAN 35 YEARS
SHAFER BEARING
DIVISION OF CHAIN BELT COMPANY
Send for Catalog #54 showing complete line of Shafer Single-row, Double-row and Self-aligning Bearings. Write to Shafer Bearing Division, Chain Belt Company, 801 Burlington Avenue, Downers Grove, Illinois.

Up . . . to 5432° F
CARBON
gets stronger
The tensile strength of carbon (in the form of graphite) actually doubles as the temperature is increased from 70° to 5432° F. That's one reason for the growing interest in carbon as a structural material for high-temperature service in rockets.
Here are some others:
*Carbon and graphite are excellent refractory materials of long standing.
*Graphite does not melt. It has a low vapor pressure but sublimes at approximately 6300° F.
*Carbon and graphite parts can be readily molded and machined.
Speer is pioneering applications of carbon where short-time strength is required at elevated temperatures. Perhaps we can share our know-how with you.
SPEER Carbon Co.
St. Marys, Pa.

people in aviation. It was one of a series of three programs.

The IAS members who took part in the television program were F. Daniel Applegate, Donald P. Germeraad, Dwight H. Bennett, and James G. Wenzel, all of Convair, A Division of General Dynamics Corporation, and William T. Immenschuh, of Ryan Aeronautical Company. The purposes and functions of the San Diego Section of the IAS were described by Mr. Wenzel, Section Chairman.

The interest in student aid activities has continued to build up with the San Diego Section. No other program has opened up so many opportunities for the membership to become active in Section activities. The work is extremely gratifying and is recognized by the schools and the membership as both a community service and a grass roots aid to industry.

D. P. Germeraad
Acting Corresponding Secretary

"Chemical Milling Processes" proved to be a challenging topic at the May 19 meeting. Frank L. Bailey, Sales Manager of the Chem-Mill Division, Turco Products, Inc., presented a complete discussion of his firm's revolutionary new process for the precision sculpturing of aircraft structures by chemical etching rather than by machine methods. A color movie showed the process in use. Sample parts in aluminum, stainless steel, and titanium were displayed.

A 30-min. TV educational program related to aeronautics was presented by members of the IAS on May 17 to all the elementary schools in San Diego. This stimulated considerable interest and brought requests for further participation in later programs.

San Francisco Section

George E. Cooper, *Secretary*

The regular dinner meeting was held on May 26 in the Stone Cellar Restaurant. A special committee, appointed by chairman Ed Quarterman, met prior to dinner for the purpose of planning for the reception and entertainment of the British visitors who were coming to San Francisco and the Ames Laboratory of the NACA after attending the joint RAeS—IAS meeting in Los Angeles.

Seventy who attended the meeting heard O. F. Oldendorph, Senior Design Engineer of Convair, A Division of General Dynamics Corporation, speak on the "Design Aspects of the XFY-1 Vertical Take-Off Fighter."

Mr. Oldendorph first outlined the mission of the VTO, which was primarily intended to supply aerial cover for

Flame tube

. . . heart of the modern turbo-jet

JET PROPULSION remained impractical until recent years. Until development of alloys that could meet the need for stability at elevated temperatures.

Today's super-sonic speeds are possible thanks to flame tubes, turbine blades and other vital parts made from high-nickel alloys.

Ever since the days of its first piston engine, the aircraft industry has used nickel alloys . . . widely. The piston engine still powers 99 per cent of all commercial planes. It will no doubt be used for years to come . . . with continued help from nickel alloys. Especially where assailed by heat or cold, corrosion or wear, steady stresses or shock loads.

Perhaps high heat . . . sub-zero cold . . . corrosion or some complex problem is troubling you or your staff. Send us the details. Let us study them. We'll give you our suggestions based on wide practical experience.

Write for . . . "List A" of available publications. A simple form makes it easy for you to outline your problem.

INCO TRADE MARK

Typical Alloys Used in Jet Engines

Part	Material	Average Nickel (%)
Combustion Liners (Flame tubes)	Inconel®	78
	Incoloy®	33
	Nimonic 75	75
	Type 310 Stainless	20
Combustion Chambers	Type 321 Stainless	9
Tail Cones	Types 321, 347, 310 Stainless	8 to 20
Afterburner	Inconel W®	74
	Inconel X®	73
	N-155	20
Buckets (Blades)	S-816	20
	Stellite 31	10
	Waspoloy	59
Wheels (Discs) Composite	4340 (hub) 16-25-6 (rim)	2 to 25
	A 286	25
	Discaloy	26
Fuel Line Tubing	Inconel	78
	Type 321 Stainless	9
	Monel®	67

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.

convoys. It was intended for operation from freighters, tankers, or any ship of a convoy. It was not intended to replace, but to supplement, the aircraft carrier.

The prime requirement for such an aircraft lay in possessing a high-thrust engine with low enough thrust-to-weight ratio. This was supplied by the Allison T-40 turboprop engine, delivering approximately 5,800 equivalent s.hp.

Convair's experience with delta-wing aircraft was traced back to the XF-92, and it was pointed out that Convair's faith in this type of wing is borne out by the fact that all its recent fighter designs incorporate the delta wing.

Particular advantages of the delta design to a VTO aircraft were pointed out as (a) good ground stability due to wide-set landing gear mounted near the tip of the modified delta surfaces and (b) a very mild gradual stalling of the wing, making possible flight at angles-of-attack above $C_{L_{max}}$, thereby aiding transition from vertical to normal horizontal flight.

Extensive wind-tunnel testing by both Convair and NACA preceded construction. Free-flight model testing at NACA's Langley Laboratory was particularly useful in studying transition. Particularly good control by elevons and rudders on each of two vertical stabilizers was obtained in the presence of the strong propeller slipstream, even at zero flight velocity.

Of particular interest was the need to rotate the pilot's seat 45° during transition and to provide for an upright battery position at all times. A special oil scavenge pump was necessary for engine operation in the vertical position. This pump automatically cut off as the pilot's seat was rotated during transition. One structural innovation brought about in this design was the need for extremely large forgings for distributing the landing loads through the relatively thin supporting surfaces. Also, the thickest skin was required at the tips rather than at the root section.

Mr. Oldendorph then described the flight program from the initial tethered flights made in the large hangar at Moffett Field to the free-flight transitions to horizontal flight made at Brown Field near San Diego. A narrative film was shown covering highlights of the flight-test program. A second film documented Convair's interest in the delta wing by showing the operation of each of its delta-winged aircraft, the XF-92, the Sea Dart, the VTO, and the F-102.

Twin Cities Section

H. C. Johnson
Recording Secretary

The May 20 meeting was called to order by Chairman Robert Hoel at the White House Restaurant in Minneapolis. He then introduced the speaker of the evening, H. Guyford Stever, Chief Scientist of the Air Force, who spoke on "Technical Barriers to High-Speed Flight."

In introducing his subject, Mr. Stever promised to deal with several problem areas of importance today and in the future. He said that it was necessary to define these problems now, even though the answers are not yet at hand.

The first area was defined as being in the transonic zone. While we have aircraft operating at these speeds today, the problems of sustained flight and controllability through the sonic region are just now being solved.

The second problem mentioned was the thermal "barrier." The rise of surface temperature with speed is a well-known phenomenon. While there are alleviating effects such as temperature recovery, radiation, etc., surface temperatures are reached in Mach 2–3 flight which are beyond safe limits for some present structural materials. Extremely high speeds will be required to fly much above 100,000 ft. At these speeds an aircraft approaches the characteristics of a satellite, and centrifugal force helps to sustain it in flight. The problem area appears to lie between 100,000 and 500,000 ft. As we now see it, flight at these altitudes is not impossible but cockpit cooling will be necessary.

The third problem was concerned with military capability—defined as the speed, range, altitude, and military-load-carrying ability of an aircraft. Of these, the range limit is extremely serious. We can build aircraft to perform well but not for long time periods. New types of engines and fuels are needed to cope with this problem. Boundary-layer control is also a potentially great improvement.

The last problem outlined was that of stability and control. Generally, this is the last problem to be considered in the design of any aircraft. Mr. Stever feels that this is regrettable, for better controllability has been achieved when an earlier consideration is taken of this problem. Characteristics of the high-speed aircraft and its environment which aggravate the controllability problem include the decreased moment of inertia in the roll axis, the shift in the aircraft center of gravity with time in flight, the high dynamic pressures encountered in flight, and the short response times required at high speeds. The difficulty of obtaining controls that function properly over the entire speed range of the aircraft is also serious. Mr. Stever concluded his discussion with the statement that stability and controllability are two of the most serious problems facing us today.

▶ The April meeting was held at the White House Restaurant in Minneapolis, with Nicholas J. Hoff, head of the departments of Aeronautical Engineering and Fluid Mechanics of the Polytechnic Institute of Brooklyn, as guest speaker.

Mr. Hoff spoke on some aircraft structural problems resulting from aerodynamic heating. He introduced his subject by mentioning that, in the near past, the sonic barrier was considered impregnable. The thermal barrier is considered in the same light today but will also be overcome.

He first discussed the problems associated with thermal stress. Fourier showed that the heat penetration of a metal rod is extremely slow. The unequal temperature distributions resulting from a sudden exposure to high-temperature conditions (kinetic or aerodynamic heating) will cause high thermal stresses to be introduced in a member from unequal expansion rates. Buckling of wings, etc., from these stresses is a serious problem in missile design. The effect of buckling was illustrated with a slide of a double-wedge airfoil that had been heated to 600°F. for 10 sec. A pronounced wave-like distortion of the edges was evident.

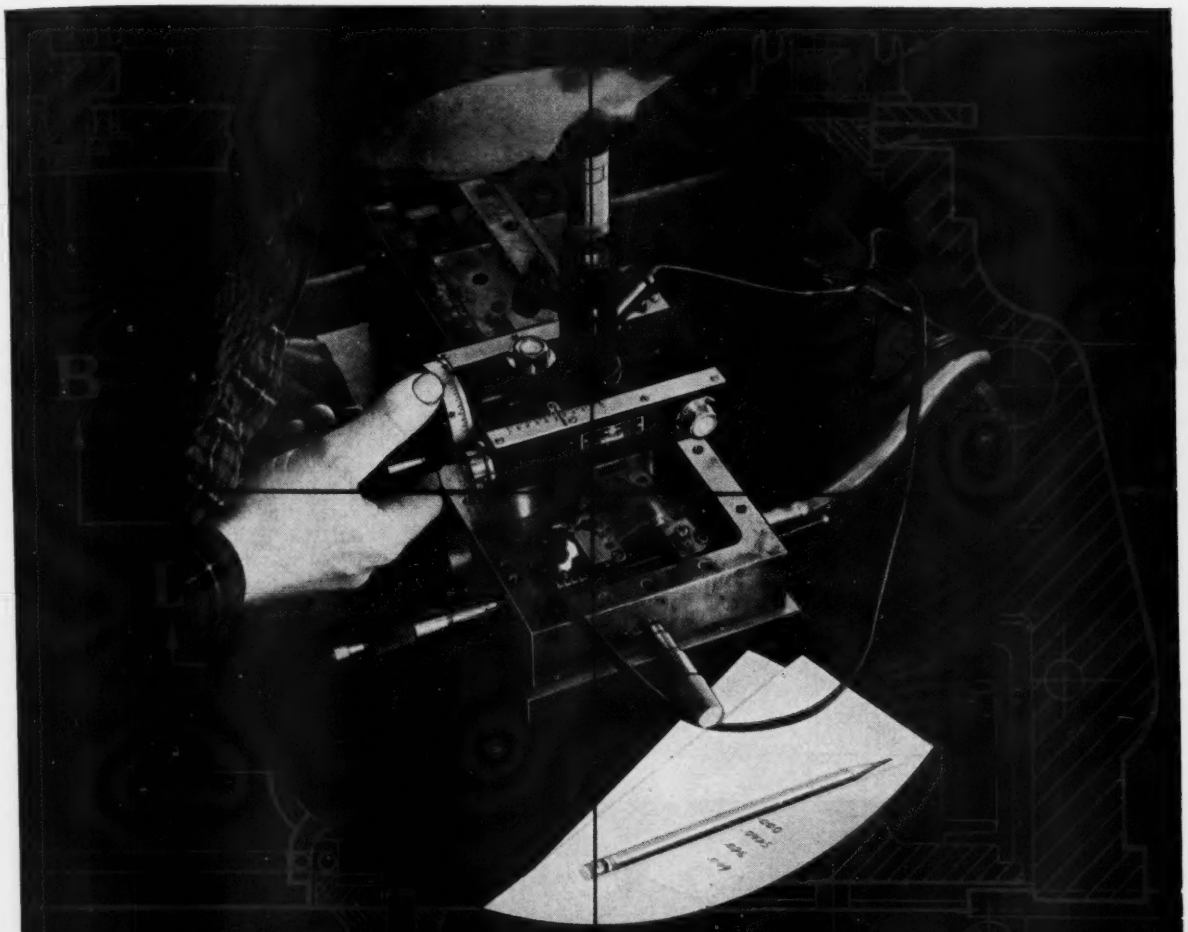
Mr. Hoff also discussed thermal creep phenomena as applied to metals. He showed that the elastic limit concept is no longer applicable since, in exact design terms, the strain of a member will vary with temperature, rate of load application, and other factors. Generally, the elongation may be expressed as a sum of three actions—Hookes law deformation, viscous deformation, and primary creep. While it is difficult to compute the actual rupture point, methods have been developed whereby this may now be done with reasonable accuracy for simple shapes.

The talk was concluded with the thought that, in the future, it would be best to express safety factors in terms of life expectancy rather than in terms of stress, because the former is a more exact definition and more applicable to the design problems of tomorrow.

Washington Section

R. Fabian Goranson, *Secretary*

The May 11 meeting took place in the International Room of the Occidental Restaurant for a discussion of "Civil Aviation." The theme of the meeting was delineated by the Honorary Chairman, Joseph T. Geuting, Jr., when he pointed out that the evening's discussion would be devoted to civil aviation other than scheduled air-line transportation. He also noted that this category of aviators logged $2^1/_2$ times as many flight hours as did the commercial air lines during the past year.



Little things that make PERFECTION

CECO

America's fighting planes depend on many *little*, extremely precise elements to deliver their k.o. punch. In CECO Turbo-jet Engine Controls, vital mating parts are held to closest tolerances; surfaces are finished to 2-4 micro-inches. Assembled and adjusted with infinite exactitude . . . many of them almost completely under specially designed, large-size, high-power microscopes . . . these mechanisms control fuel flow with the extreme accuracy essential to optimum performance.

Here at CECO are the engineering abilities . . . manufacturing know-how and equipment . . . the attention to little things . . . that bring perfection always closer.

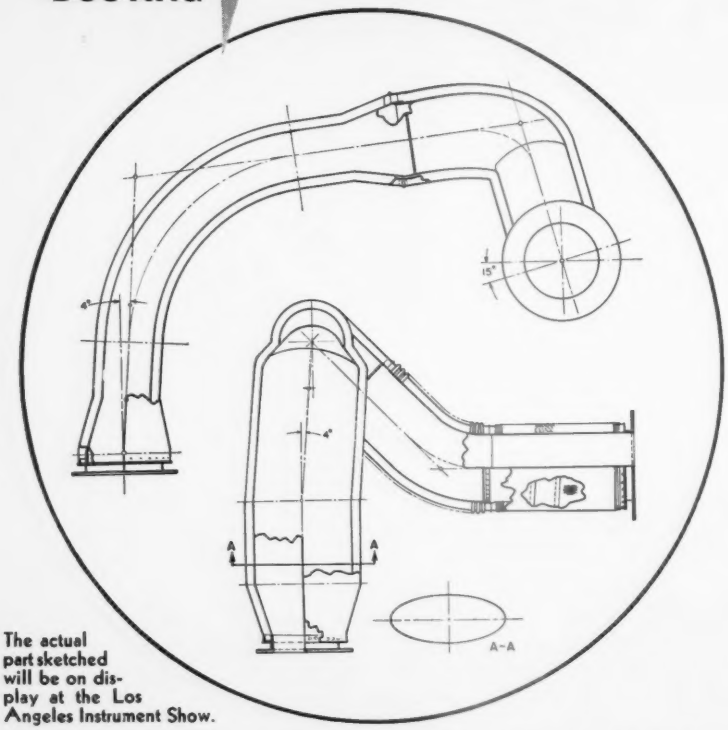
CHANDLER • EVANS

DIVISION NILES-BEMENT-POND COMPANY
WEST HARTFORD 1, CONN., U.S.A.

PIONEER PRODUCERS OF
JET ENGINE FUEL CONTROLS • AFTERBURNER CONTROLS
PUMPS • SERVOMECHANISMS • CARBURETORS • PROTEK-PLUGS

FLEXON INSULATED DUCTING

combines circular, elliptical and flexible sections



The actual part sketched will be on display at the Los Angeles Instrument Show.

Check FLEXONICS for any of these components

FLEXON DUCTING, standard or high strength corrosion resistant, is available in varying wall thickness in light gauges and in a complete range of sizes, with or without insulation. Elbow forming and rib reinforced types can also be supplied in Type 321 and Uniloy 19-9DL.

FLEXON METAL HOSE, corrosion resistant, is manufactured in the broadest varieties of sizes and types for all aircraft applications.

FLEXON BELLOWS are made in an almost unlimited range of sizes and types to meet the most advanced requirements.

The ducting assembly illustrated above is typical of many intricate sections developed and fabricated by Flexonics to meet the rigid demands of high performance aircraft.

This particular unit is made for a new high altitude fighter and is designed for operating temperatures up to 760° F. Unusual in its design is the combination of circular, elliptical and flexible sections. To provide required uniformity, it is formed from Flexon straightwall stainless steel tubing, not half shells, welded together. The entire unit is insulated and the insulation sealed in a stainless steel outer shell to prevent wicking of volatile fluids.

Flexonics Corporation's ability to fabricate ducting of this type results from over 53 years' experience in the manufacture of flexible metal components. Put this know-how to work for you . . . it is your best assurance of getting the quality you need in your ducting requirements. For specific recommendations on the resolution of your ducting problems send an outline of your requirements.

Flexonics Corporation — AIRCRAFT DIVISION

1309 S. THIRD AVENUE • MAYWOOD, ILLINOIS

FORMERLY CHICAGO METAL HOSE CORPORATION

Flexon identifies products of Flexonics Corporation that have served industry for over 53 years.

Manufacturers of flexible metal hose and conduit, expansion joints, metallic bellows and assemblies of these components.
In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ontario

J. B. Hartranft, Jr., President of the Aircraft Owners and Pilots Association, reviewed the general status of private flying, pointing out that there were 43 civilian aircraft per scheduled air liner, 52 pilots licensed for each air-line pilot, 1,403 privately owned multiengined airplanes, and 2,604 business-owned multiengined airplanes. He stressed the particularly difficult problems in providing adequate and economical airports occasioned by the increase in this type of flying—there are now only 1,331 airports with paved runways and only 1,102 lighted for night landings. In order to improve the safety of private and business flying, it was obvious that much effort must be placed on improving airports and increasing the number of all-weather landing strips. He felt that considerable economy could be effected if plans were made to use single-direction landing strips. Mr. Hartranft closed his report on the note that there was great need for understanding and willingness to work together among the various groups, particularly military and civilian units, who are interested in utilization of airspace and airports.

Jean H. Dubuque, speaking on aviation, suggested that one of the biggest deterrents to business flying was the lack of airplanes specifically designed for this purpose. Most air planes being used today are conversions of semiobsolete, small transport or military airplanes not always suited to the job nor designed to be efficient in this type of operation. Mr. Dubuque reported that 70 per cent of all business flying is off the airways and that airplanes devoted to business flying increased from 2,500 in 1946 to 21,500 in 1954. He also noted that, contrary to common belief, the business airplanes were not reserved for the business tycoons but actually were more often used by executives, engineers, and sales personnel, because this type of travel permitted point-to-point transportation with a saving of time, as well as wear and tear, for the valuable personnel. He also noted that private business flying had added to commerical flying, not detracted from it. One company, he said, increased the travel card holders from 25 to 200 since purchasing its own airplane. He gave many interesting examples of how the pickup and delivery of potential customers, or direct travel by business executives or salesmen to potential customers, had materially increased the company's earnings. He also discussed the novel methods used by some corporations to pay for their airplane operations and gave typical examples of the large and small private flying operations conducted by members of his association.

J. Roy Allgyer reported on the use of airplanes in agriculture and related operations and presented some interest-

FAMOUS FOR POWER PACKAGES AND OVER 30,000 OTHER AIRCRAFT PARTS!

ROHR is famous as the world's largest producer of ready-to-install power packages for airplanes . . . like the Lockheed Constellation, Douglas DC-7, the all-jet Boeing B-52 and other great military and commercial planes.

But that's not all!

Today, in addition to power packages, ROHR'S engineering skill is going into the production of over 30,000 other different parts for aircraft of all kinds . . . many of these requiring highly specialized skill and equipment.

Whatever the aircraft part . . . whenever you need it . . . call on ROHR. Call on the engineering skill and production know-how gained from the thousands upon thousands of power packages and over 30,000 other aircraft parts that have made ROHR famous.

WORLD'S LARGEST PRODUCER

OF READY-TO-INSTALL POWER PACKAGES FOR AIRPLANES

– RECIPROCATING, TURBO-PROP, TURBO-COMPOUND AND JET*

ROHR

AIRCRAFT CORPORATION

CHULA VISTA AND RIVERSIDE, CALIFORNIA

*A trade name of Curtiss-Wright

ing data. He pointed out that one-sixth of the cultivated acreage is being treated annually by the use of airplanes and that, if all the dust spread by airplanes last year were collected in one place, it would fill 1,000 freight trains of 50 cars each. He reported on the use of airplanes in soil conservation and in preparation of inexpensive land surveys and also discussed some unusual uses, such as those involved in grasshopper control by spreading poisonous food, bug control by spreading viruses that kill the bugs, and control of cattle flies. Mr. Allgyer reviewed special problems of using airplanes in agriculture which stem from the fact that these airplanes must be designed with operating characteristics almost opposite those of airplanes used in normal flying and that each operation, such as handling dust sprays or granular insecticides, has its peculiar problems. He noted that considerable progress is being made toward developing special airplanes for these purposes and that the Department of Agriculture and industry are cooperating in establishing the specifications.

The meeting was concluded with a lively discussion of the material presented by the speakers. It was the consensus that all present left with a better understanding of the problems and progress made in general civil aviation.

Student Branches

The Aeronautical University

John R. Lundberg, *Secretary*

A tour of the Air National Guard facilities at O'Hara Air Force Base, Park Ridge, Ill., was made on May 19. Leland W. Sims, Faculty Adviser, and all members were present.

Lieutenant Col. Donald Smith, Commander of the 126th Fighter-Bomber Wing, conducted the tour through shops, hangar, ready rooms, and storerooms. The Guard had been flying F-51's but recently received 30 F-84 Thunderstreaks, and the pilots were making the transition to the newer jet aircraft.

Many of the planes were torn down for repairs—affording a good opportunity to see all parts of the J-65 jet engine, which has an annular combustion chamber and a two-stage turbine. The airplane is a swept-wing, tricycle-landing-gear type with a new feature called a "flying tail," which is nothing more than an adjustable stabilizer.

Brown University

David Peterson, *Secretary*

The season's final meeting was held April 27 in the Pine Room, located in the Engineering Building. Twenty members were present. Several movies, including one on guided missiles, were shown before the speaker was introduced.

After Phil Jarvinen opened the meeting, Gordon Anderson of the Aerodynamic Research Laboratories of Brown University presented a talk on "Guided Missiles." He discussed the probability of destruction of enemy aircraft by present types of missiles. He then compared the hitting probabilities if atomic warheads were used. The many problems of missile guidance and of construction, propulsion, and aerodynamics were pointed out.

The business session consisted of the Secretary-Treasurer's report and the election of officers. James Mears was chosen Chairman for next year and David Peterson, Secretary-Treasurer. More movies were shown at the end of the meeting.

Georgia Institute of Technology

Robert E. Drowns, *Secretary*

Thirty members were present at the May 16 meeting held in the Aeronautical Engineering Building. Roland Fuentes presided.

Allen C. Klepper was elected to represent the IAS on the Activities Council. An outing for members and their guests was planned for May 28.

A film entitled *Aerodynamic Airflow* was shown. It explained the basic characteristics of airflow about an airfoil. The film discussed lift, drag, and turbulence and showed their application from the flat plate to the streamlined airplane.

Iowa State College

Robert Dighton, *Secretary*

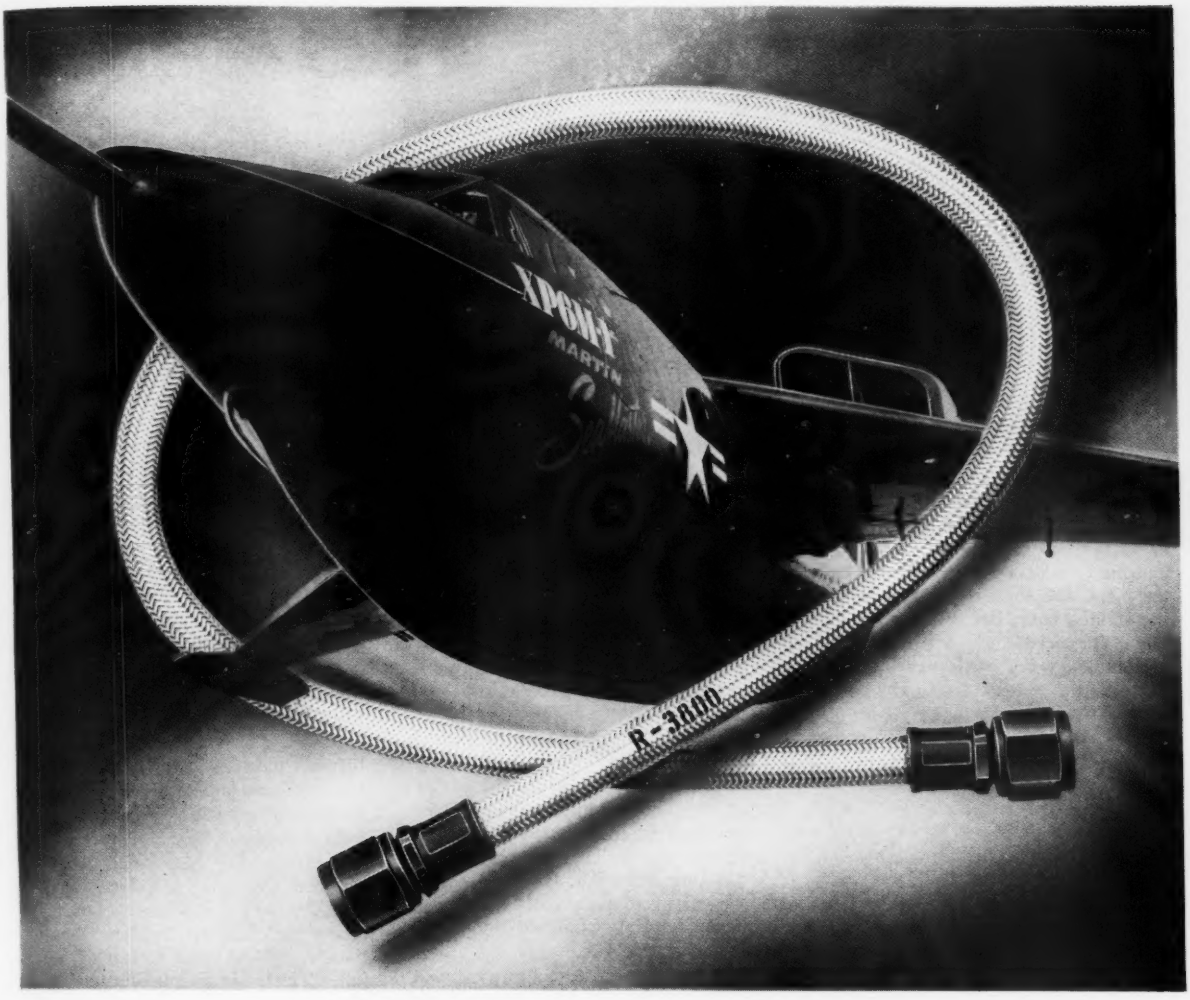
Chairman Arden Boyd conducted the May 4 meeting in Marston Hall. Glen Christoffersen reported on the recent proceedings of the Engineering Council. The Engineering Council will hold a reception for freshmen during Orientation Week next year. Dave Werts reported on activities of the Veishea Committee.

John Midgordon and Jim Bowans, both seniors, described the Third Annual Southwestern Student Competition that they attended in Fort Worth, Tex. John covered the reports presented at the contest. He said the papers were of two general types: either pure research or the accumulation and summation of existing material. Jim reported on the trip and activities associated with the contest. He said the contestants and advisers were entertained at numerous dinners and luncheons at which engineers and officials of aircraft plants in the Forth Worth area spoke. In addition, the contestants were taken on tours of the Bell, Chance Vought, Convair, and Temco plants. Colored slides were shown by Jerry Walter, a freshman. He had made the photos while serving as crew chief on a B-47. The collection included shots of the B-47 on the ground and in the air and other photos of planes exhibited at the Detroit Air Show in 1952. Two dozen members attended the meeting.

▶ At the April 20 meeting Jim Iverson, Co-Chairman of the Open House for Veishea, said that a cutaway model of an Allison J35 jet engine had been obtained for the exhibit, which also will include the wind tunnel, a vibration testing device, and a schlieren apparatus.

Karl Hagenau, a senior student, gave a talk on "The Shortcomings of High-Speed Aircraft." The main point of his speech was that, in the design and manufacture of high-speed aircraft, a compromise has to be made between the needs of the pilot and the performance of the plane. He stated that the instruments now in use must be made more efficient and new instruments must be developed before high-speed air craft can be expected to attain their full capabilities. Mr. Hagenau stated that the instruments in most need of improvement are the altimeter, vertical rate of climb indicator, and Machmeter. The altimeter needs to be more accurate, the vertical rate of climb indicator needs more range, and the Machmeter needs to be made more efficient and accurate. The report also contained the information that Hughes Aircraft Company Division is now conducting research on methods of improving old instruments and developing new instruments.

Everett Dencklau, also a senior, gave a seminar report on chemical milling of metal. This is a method of removing metal by chemical etching. The metals on which this method of milling are used are aluminum, titanium, magnesium, and some of the steel alloys. Mr. Dencklau stated that at the present time this method is used mostly on aluminum. The piece of metal to be milled is put through a preparation process that includes greasing the piece, deoxidizing the surface, washing with hot water, and drying. This process varies with the material and particular chemical being used for the milling. After the piece has been prepared, it is put in the etching bath. By adding heat, the process can be controlled, and, with the use of a depth monitor, the milling can be controlled to plus or minus five thousandths of an inch. If a



Weight-saving 450°F FLUOROFLEX-T "plumbing" in the MARTIN SeaMaster and its 4 engines

The world's first multi-jet attack seaplane uses the world's first Teflon-compound hose.

Fluoroflex®-T R3800 hose assemblies are used to convey fuel and oil, and as vent lines in the sleek SeaMaster . . . and are on its four powerful turbojet engines too. All in all, they add up to a sizable saving in weight over other hose types.

Fluoroflex-T lightweight, corrosion-resistant lines are made with Teflon® compounded tube, 304 stainless steel braid, and blowout-proof fittings. Their flexibility stays the same from −100°F to +450°F . . . indefinitely.

R-3800 assemblies are Service approved for synthetic fuels, oils. You'll be hearing about them in more and more engines, airframes and missiles, where they solve high temperature operating problems. For more data, ask for Bulletin FH-2.

®Fluoroflex is a Resistoflex registered trade mark for products from fluorocarbon resins. Teflon is the DuPont registered trade mark for its tetrafluoroethylene resin.

RESISTOFLEX

CORPORATION

Belleville 9, N. J. • Western Division: Burbank, Calif.

Our 18th year of service to key industries

P.S. *Fluoroflex-T spiral back-up rings—another Resistoflex product from fluorocarbon resins—are also in the SeaMaster, contributing to the reliable performance of hydraulic control circuits.*

Michael Witunski, adviser for the supersonic wind tunnel being constructed by students at Parks College of Aeronautical Technology, discussing it with officers of the IAS Student Branch. *Left to right:* Floyd Wohlrab, Treasurer; Michael McAlister, Secretary; Mr. Witunski; and John Vincze, Chairman.

uniform thickness is to be removed from the piece, the piece is simply placed in the etching bath, but, if a certain portion of the piece is not to be etched, this portion is covered with a masking tape or a covering of some type. The cost of this process is 40 cents per sq.ft. to prepare the piece and 40 to 50 cents a pound for the etching. Although this cost compares favorably with other types of milling, the real saving is in time since the piece can be placed in the etching bath and requires only the labor to reremove it from the bath. This type of milling has been used up to this time for removing mill scale from hot rolled metals and for making sandwich construction parts.

Parks College of Aeronautical Technology

Michael J. McAlister, *Secretary*

The first meeting of the summer semester was held on May 12. Twenty-five members were present and John Vincze presided. Business discussion centered on constitution revisions and the supersonic wind-tunnel exhibit that the Branch was preparing for Parks College Open House.

Before the speaker was introduced, NACA Technical Film No. 27 was shown. It described the methods and materials used in constructing models to be tested in the wind tunnels at Langley Aeronautical Laboratory.

Michael Witunski, of Sverdrup & Parcel, Inc., a consulting engineering firm of St. Louis, spoke on the topic "Wind Tunnels in General and the Parks Supersonic Wind Tunnel in Particular."

He opened his talk by stating the need for empirical experiments which is brought about by the inaccuracy of purely mathematical computations. He outlined the history of the wind tunnel from the first one constructed in England by the Royal Aeronautical Society in 1871 to the current Tullahoma Project sponsored by the U.S. Air Force. Wind tunnels must be designed and built several years in advance of the aircraft they are to benefit, he said, so that wind tunnels of the proper type will be available when needed by aircraft designers working on new planes. As an example, he cited the difficulty of designing the Bell X-1 rocket plane. At the time, transonic wind tunnels had not been invented, and there was not sufficient test data available from supersonic wind tunnels.

The Parks wind tunnel is a student project that M. Witunski initiated. He is the adviser and moderator of this undertaking. The tunnel has been designed for speeds up to Mach 4 and will have a test section 10 in.^{2}. The compressors were taken from Westinghouse J-30 turbojet engines. They will be driven by one or more Pratt & Whitney R-4360 piston engines. There is no budget on this project; all the work is being done by students under faculty supervision. The tunnel is expected to be in operation by the end of December. This addition to the Engineering Department's equipment will enable the students to gain valuable experience in the operation of a supersonic wind tunnel.

At the Parks College Open House, which was held May 15, the IAS Student Branch received first prize in the competition for the best exhibit. The exhibit consisted of a model of the proposed wind tunnel, engineering plans for the tunnel, one of the engines that will power the compressors, and a 6-ft. wind-tunnel model of the McDonnell XF-88. IAS Student Member Paul Czysz stood by to explain fine points of the exhibit. The $25 prize will go toward the Branch's annual banquet.

The Pennsylvania State University

E. Allen Weber, *Secretary*

The season's last meeting was held on May 26, with 40 members present. Ralph Straley presided.

As the meeting was primarily for business purposes, it was opened with a discussion of what to do with the money left in the treasury. The most popular suggestion was to spend it on a picnic at one of the nearby state parks. The date was set for Saturday, May 28.

The following officers were elected for next year: Chairman, Richard Moore; Vice-Chairman, Russel Meyers; and Secretary-Treasurer, Joel Peterson.

Two films were shown, one on the Boeing 707 jet transport and the other on the Piasecki YH-16 40-passenger helicopter.

Purdue University

William R. Long, *Secretary*

Forty members attended the last meeting of the school year on May 17. There was a discussion of the advisability of lengthening the faculty sponsor's term from one semester to two semesters. The matter was tabled until the first meeting in the fall. After the business meeting, a movie, *We Saw It Happen*, was shown.

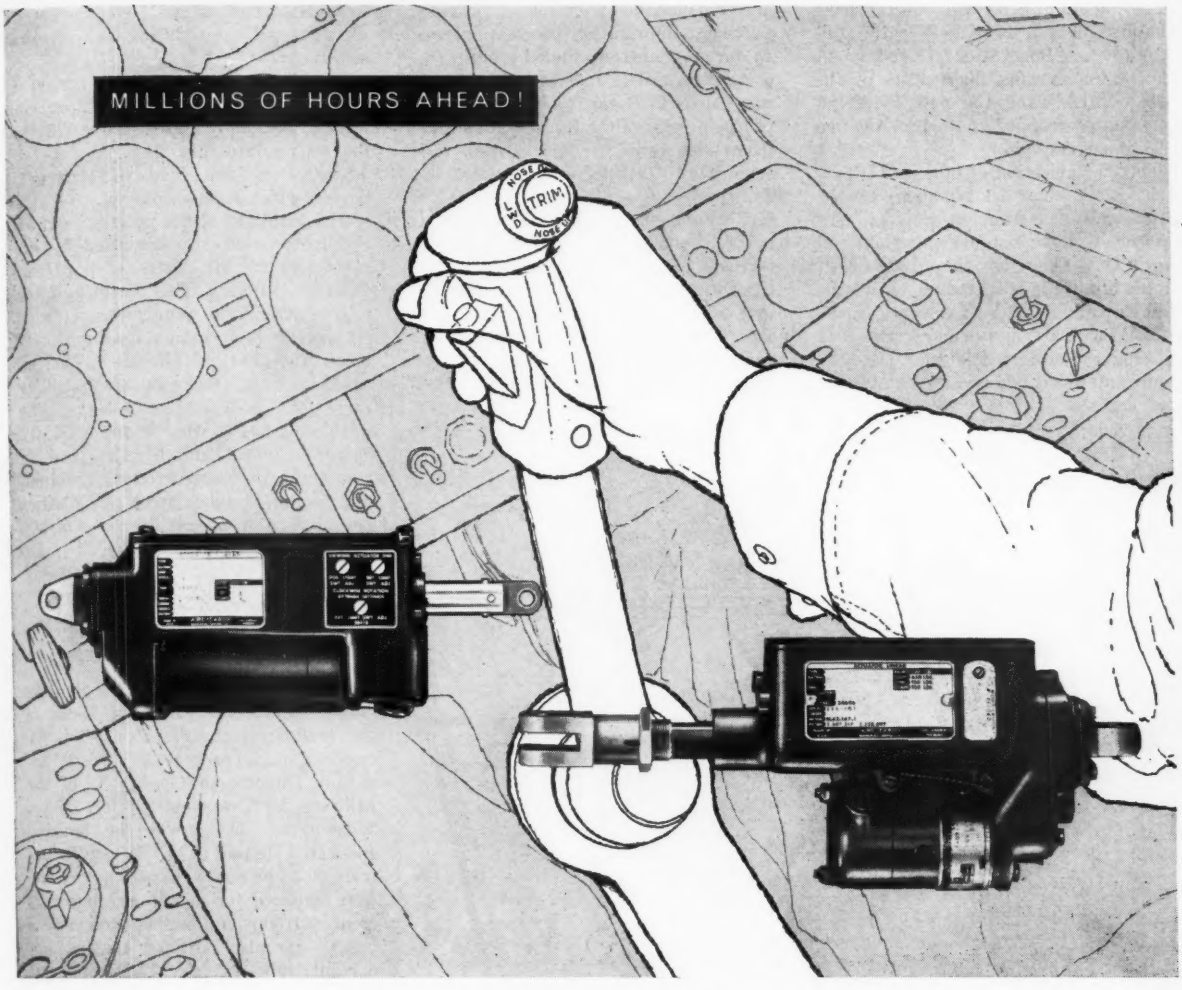
▶ Next year's Branch officers were elected on May 10. Lionel Wilson is the new Chairman; Robert Monger, Vice-Chairman; William R. Long, Secretary; and Stanley Groover, Treasurer. Faculty advisers will be chosen in the fall. Thirty-six members attended the meeting and saw a film entitled, *Fighter-Bomber Attack on a Mechanized Convoy.*

San Diego State College

Bob Parker, *Secretary-Treasurer*

On May 10, a talk was given by William Ivans, Chief of Electronics Engineers at Convair's San Diego plant and holder of the world's altitude record for single-place sailplanes. His record of 42,100 ft. was made flying over Bishop, Calif. Mr. Ivans gave a highly interesting talk describing the flight characteristics of the sailplane and the unusual problems encountered in powerless flight. He showed a color movie, shot both from his sailplane and from the ground, which provided a vivid picture of the thriils encountered in thermal soaring. Mr. Ivans conveyed a high degree of enthusiasm in his presentation, and, judging from the response to his talk, it looks as if the local sailplane clubs will have several new members in the near future.

▶ The April 26 meeting was devoted to a motion picture entitled *The Supersonic Wedge*, which told the story of the



Now...stick-feel for jets at half 1 lb. 2 lb. the weight!

Aerodynamic pressures generated by the tremendous speed of jet planes made it necessary to power their control surfaces. This left the pilot of the airplane without any "feel" control through his stick.

Actuators were needed to supply this stick "feel"... and they had to be of minimum weight and size.

To meet these requirements AiResearch designed highly-efficient units as light as two pounds. Now an even smaller stick "feel" linear actuator has been developed by AiResearch. It handles operating loads up to 150 pounds... static loads to 500 pounds *— and it weighs only one pound!*

It is the smallest, lightest unit in this field! Again AiResearch shows its ability to top previous performances with a smaller, lighter power package.

In the past decade AiResearch has developed and produced more than 350,000 actuators for every possible aircraft application. Why don't you put the proved ability of this high-quality engineering and manufacturing team to work on your problems? Your inquiries are invited and will receive immediate attention.

Qualified scientists, engineers and craftsmen are needed now. Write for information.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Designers and manufacturers of aircraft components: REFRIGERATION SYSTEMS • PNEUMATIC VALVES AND CONTROLS • TEMPERATURE CONTROLS CABIN AIR COMPRESSORS • TURBINE MOTORS • GAS TURBINE ENGINES • CABIN PRESSURE CONTROLS • HEAT TRANSFER EQUIPMENT • ELECTRO-MECHANICAL EQUIPMENT • ELECTRONIC COMPUTERS AND CONTROLS

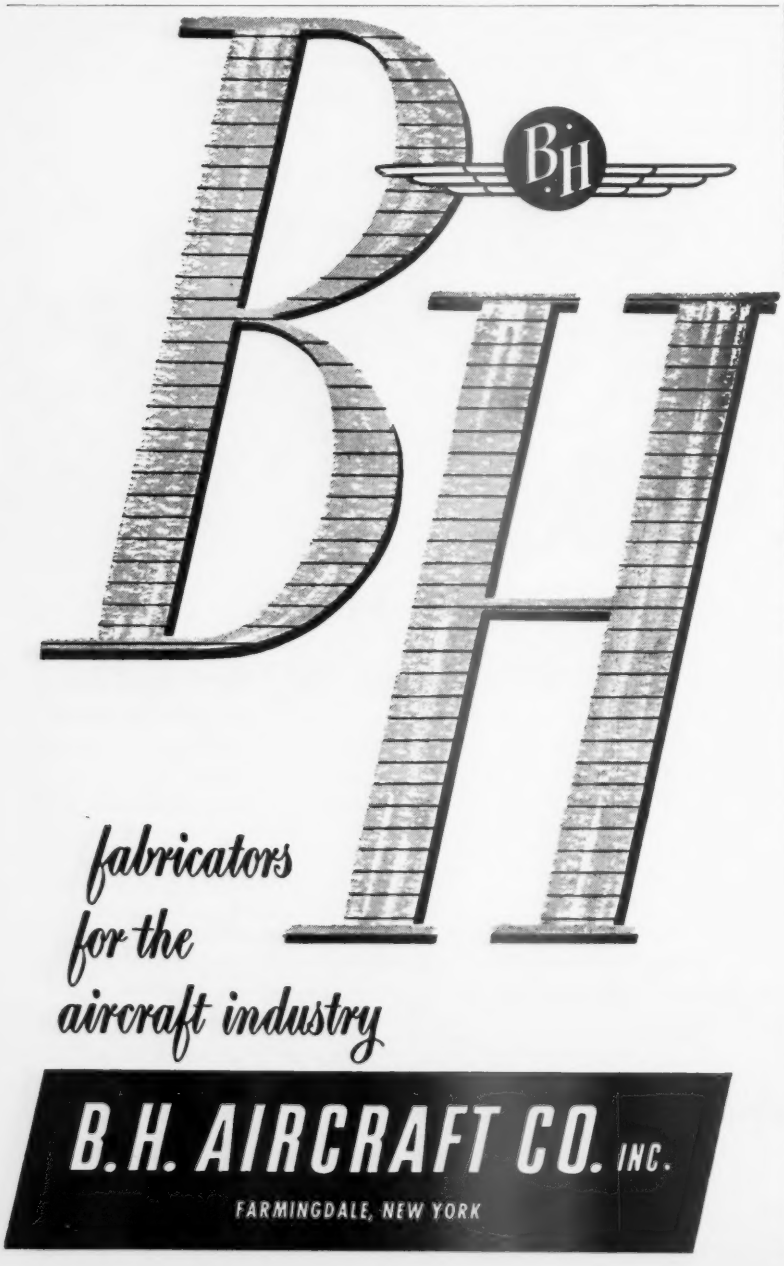
development of delta-wing aircraft from the first flight tests in 1948 of the XF-92A to the "Pogo Stick" of today. A short film showing flight tests of the "Pogo Stick" and the new F-102 jet interceptor wrapped up the program in a real supersonic vein.

▶ On the invitation of officials of Convair, more than 20 members of the Student Branch went on a guided tour of the Convair-San Diego plant on April 19. They saw the Univac electronic brain, the wind tunnel, chemistry lab, electronics lab, load testing lab, the XF2Y Sea Dart, and demonstrations of jet-engine testing. The tour lasted 4 hours and was conducted by members of the engineering staff, who provided pertinent information of great interest to our aeronautical-minded group.

▶ At the April 12 meeting, the speaker was Curtis L. Bates, Assistant Director of Engineering of the Ryan Aeronautical Company here in San Diego. His topic was "Engineering Development Projects at Ryan," which included a highly interesting coverage of the engineering problems of today and the future and some of the projects that are currently under way which should provide solutions. Some of these problems are: cockpit visibility, temperature control, heat problems as the result of supersonic speeds, landing and take-off difficulties encountered by high-speed aircraft, and the resulting lack of suitable runways.

Ryan, he said, is now working on a vertical take-off jet aircraft that will have to develop a thrust of over 20,000 lbs. Mr. Bates also pointed out the advances in the field of electronic devices which Ryan is making.

The highlight of the program was an excellent movie, supplemented by explanations by Mr. Bates, of the Ryan "Firebee" drone. This versatile drone missile provides a gunnery target with jet aircraft performance for about one-tenth the cost of aircraft converted to drone use. It can be assembled by three men in less than 1 hour. The "Firebee" has a wing span of 12 ft., height of 6 ft., and length of 18 ft. This aircraft is constructed of aluminum, magnesium, stainless steel, and plastics and can attain speeds in excess of 300 m.p.h.



Tri-State College

Lawrence Crowley, *Chairman*

A banquet was held May 25 at Twin Gables, Columbia, Ohio, in honor of the graduating members. On this occasion Col. Lawrence G. Gilbert, Assistant Director of Operations of the Military Air Transport Service, USAF, Washington, D.C., was the honored speaker. He told of MATS' continuous training to be ready in case their efforts were required for an all-out air movement of troops and supplies to overseas bases. He also outlined another important function of MATS—the air evacuation of sick and injured from overseas bases to the zone of interior and from there to the various military hospitals within the zone of interior.

At the banquet, Robert Spatz of Bruno, Neb., received the IAS Scholastic Award from the Civil Society's Honorary Chairman, Quintin J. Hawthorne, for the highest scholastic standing of the graduating members. This award is presented semiannually. Lawrence Crowley presided at the banquet.

John O'Briant, of Washington, D.C., has been elected to head the Tri-State Student Branch next year.

▶ A group meeting in conjunction with the Civil Society was held on the campus the evening of April 25. At this meeting Al Tucker, a Tri-State graduate and at the present time Chief of Component Design for the Columbus Division of North American Aviation, Inc., spoke to the group of the manner in which N.A.A. incorporates the various types of engineers in the engineering phase of producing their aircraft.

▶ The 2-day field trip of April 14 and 15 was attended by 25 members of the Society. This trip included a visit to

TONS OF POWER

AT HIS FINGERTIPS!

...And Sargent precision aircraft controls make that power instantly available at the touch of a finger.

The design and manufacture of precision equipment has been the specialty of Sargent Engineering Corporation for more than 35 years. For 20 years Sargent has been providing precision aircraft control units—hydraulic, pneumatic, and mechanical—for the country's leading airframe manufacturers.

We have the "know-how" to help you solve your most difficult control problems. *Write today for your copy of the NEW illustrated story of Sargent's organization, methods, and manufacturing facilities.*

Standard of Excellence

Sargent

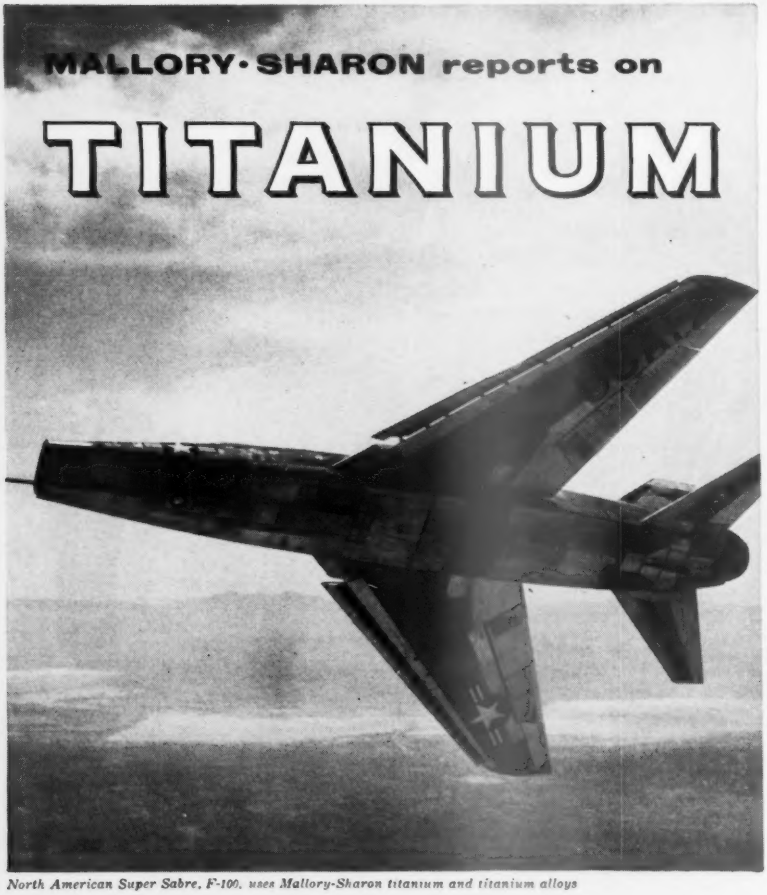
Since 1920

ENGINEERING CORPORATION

2533 EAST 56TH STREET

HUNTINGTON PARK, CALIF.

"Good will" is the disposition of the pleased customer to return to the place where he has been well treated.
—U.S. Supreme Court



North American Super Sabre, F-100, uses Mallory-Sharon titanium and titanium alloys

Diet of titanium

SAVES WEIGHT, ADDS MUSCLE

SAVING weight is a goal almost fanatically pursued by aircraft designers. The reason is simple. By reducing the total weight of an aircraft by one pound, an additional *five pounds* of airframe structure can be eliminated. This saving can be translated into extra speed, range, or firepower.

Thus, in the latest fighter planes like the F-100, lightweight titanium replaces steel to yield weight savings in the hundreds of pounds. In the near future, titanium will save thousands of pounds per plane. This can mean the difference between first rate and second rate, between winner and loser.

Mallory-Sharon is a leading producer of titanium . . . supplying virtually every major aircraft and jet engine manufacturer with sheet, strip, bars, forgings, and other mill products. Use our experience in your applications of lightweight, corrosion-resistant titanium.

Mallory-Sharon Titanium Corporation, Niles, Ohio.

MALLORY Ti SHARON

Allison's Powerama display and a tour of McDonnell Aircraft Corporation.

The field trip group was conducted through the Powerama display by members of Powerama personnel. After the group had lunch in the Allison cafeteria, M. E. Cones of the Personnel Division reviewed the history of the Allison Division—how it evolved from its start in the engine building for 500-mile race cars to the jet engines of today. A film entitled *ABC's of Jet Propulsion* was shown.

The following day, after motoring to St. Louis, the Society's members were cordially received by a group at McDonnell. A comprehensive tour of McDonnell was made, highlighted by two events: an actual drop-test of an FH-3 Demon, made in the Physical Test Department, and a landing of the new F-101 Voodoo with its roll-out shortened by "popping" a drag chute.

Raymond Daletta, Technical Placement Supervisor for McDonnell, while saying good-by to the group, presented each member with a large color picture of the Demon and the Voodoo.

▶ On February 28, representatives of the Columbus Division of N.A.A. held a group meeting on the campus. It was conducted by R. J. Theibert, of the Personnel Division, and R. Tank, of the Weights Group, who outlined some of the problems encountered in the building of the F-86 Sabre Jet and spoke briefly on the stability characteristics of the F-100 Super Sabre. The meeting included the showing of several films, one of which depicted the humorous activities of some pilots when a group of new F-86's arrived in Germany.

University of Illinois

James H. Baker, *Secretary*

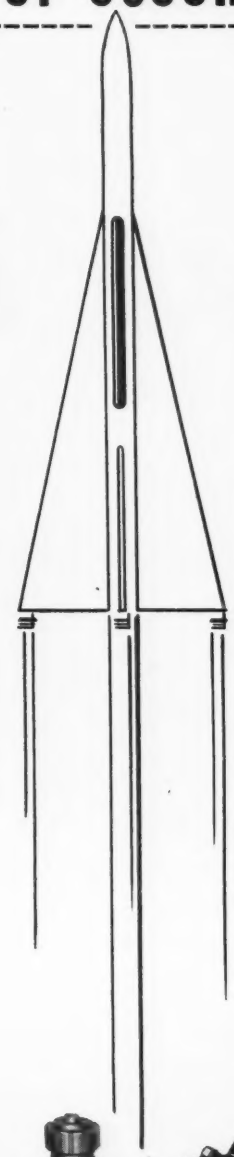
The IAS Student Branch held its annual spring banquet in conjunction with the University of Illinois Chapter of Sigma Gamma Tau on the evening of May 25.

After dinner, IAS Chairman James Kuczma presented the toastmaster, Harry H. Hilton, who is the IAS Faculty Adviser. Mr. Hilton introduced the guest speaker, Leslie Bryan, Director of the Institute of Aviation of the University of Illinois.

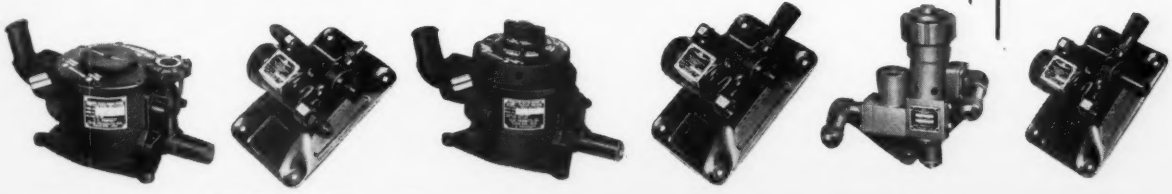
Mr. Bryan gave an interesting talk highlighting the first 50 years of aviation in America. Some milestones he mentioned were the flights of the Wright brothers, the contributions of Glenn Curtiss, early advances in Naval aviation, Lindbergh's transatlantic flight, aircraft traffic-control development, development of jet propulsion, accomplishments of supersonic flight, and the coming-of-age of the helicopter. His interesting sidelights on personalities in aviation through the years gave the

over 9 miles up in a matter of seconds

with ALAR AUTOMATIC REGULATORS



Simulating a rate of climb far exceeding that for the fastest planes, Alar oxygen regulators are proven under conditions more severe than those ever encountered in normal flight. At the final inspection panels shown, each unit must pass thirty-seven check points requiring fifty-nine separate readings. Yet such rigid testing is but one of the important factors that guard Alar dependability. For in addition, each Alar product reflects a wealth of manufacturing experience . . . plus a laboratory devoted exclusively to the study of precision controls. You will find our staff uniquely equipped to help you with your instrumentation problems. Write for details today.



Specialists in the design and development of dependable pressure regulating instruments

ALAR PRODUCTS • INC.

1071 POWER AVENUE • CLEVELAND 14, OHIO

George Goldbaum, Research Engineer with the Defense Research Laboratory of The University of Texas, addressing the April meeting of the IAS Student Branch in the University's Home Economics Tea House.

audience some insight into the personal aspects involved in the progress of aviation in this country.

University of Kansas

Marjorie Heard
Secretary-Treasurer

Our members have been doing well in paper competitions. We were represented at the Third Annual Southwestern Student Competition of the Texas Section by Dinh Ang Dang, whose paper was entitled "Compressible Turbulent Boundary Layer Displacement Thickness with Heat Transfer," and by Donald T. Higdon, who wrote on "Theory and Use of a Simple Hot-Wire Anemometer." Dang tied for third place in the undergraduate division.

In the Student Paper Competition sponsored by the St. Louis Section, second prize went to James Sorem for his paper on "Lift Loads on the Horizontal Tail of an L-13 Airplane," and third prize went to Donald Gates for "Comparison of the Theoretical and Experimental Deflection of a Model Tension-Field Beam from the Measured Properties of the Materials." William Mains, Jr., won honorable mention for "A Comparison of the Ultimate Loads Carried by Small Wagner Beams to the Theoretical Ultimate Loads." Don Gates also received honorable mention for the oral presentation of his paper.

Twelve students and two staff members attended the tour of the McDonnell Aircraft Corporation plant which was sponsored by the St. Louis Section, May 5.

The Aeronautical Engineering Department tied for third place during the annual University of Kansas Engineering Exposition. Much of the planning for this exhibit was done by the IAS Student Branch.

New officers of the Branch are: Chairman, James D. Woodward; Vice-Chairman, Robert E. Henckel; and Secretary-Treasurer, Marjorie A. Heard.

The University of Texas

Burlin Griffin, *Secretary*

A dinner meeting was held on April 19 at the Home Economics Tea House. George Goldbaum, Research Engineer with the Defense Research Laboratory of the University, spoke on "A Review of Aerodynamic Projects at the Defense Research Laboratory." His talk included work on the design and development of a variable-Mach-Number nozzle for a supersonic wind tunnel.

Plans for the annual Power Show, scheduled for May 6 at the University, were discussed. It was decided to build our exhibit around a model of a manned earth orbital satellite.

University of Washington

Gilbert Lee
Recording Secretary

Chairman Bud Nelson opened the May 18 meeting in the Student Union Building and then introduced Malcolm Matthews, an aeronautical engineering student who spoke on "Tandem Wing Configurations." Mr. Matthews based his talk on data he obtained from wind-tunnel testing of a tandem wing configuration. He showed slides of lift and polar curves that indicated good stalling and pitching moment characteristics for this configuration. He said the purpose of the tests was to find wing positions producing optimum desirable aerodynamic characteristics.

IAS awards were presented by Victor M. Ganzer, Executive Officer of the Aeronautical Engineering Department, to Don Keppler, graduating senior with the highest scholastic average, and to Mr. Matthews for the best student speech. About 35 members attended the meeting.

These officers have been elected for the 1955–1956 term: Bud Nelson, Chairman; Dale Jensen, Vice-Chairman; Al Thomas, Secretary-Treasurer; and Gilbert Lee, Recording Secretary.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Erwin, John R., B.S. in M.E., Head, Cascade Aerodynamics Branch, NACA, Langley Field.

Hatcher, Robert S., M.S., Rear Adm., USN; Asst. Chief, R&D, BuAer, Navy Dept.

Wells, Robert L., M.S.M.E., Asst. Chief Engr., AGT Div., Westinghouse Electric Corp.

Young, Alec D., M.A., Prof. & Head of Aero. Engrg., Queen Mary College, Univ. of London.

Transferred to Associate Fellow Grade

Gregory, Alfred T., Dr. Ing., Chief Engr., Head, Research & Advanced Engrg. Dept., Fairchild Engine Div., Fairchild Engine & Airplane Corp.

Lazarus, William C., B.S. in M.E. (Aero.), Tech. Adviser, Deputy Chief of Staff—Operations, Air Force Armament Center, Eglin AFB.

Miskam, Frederick C., B. of Ae.E., Design Specialist, Douglas Aircraft Co., Inc. (Long Beach).

Newton, Floyd C., Jr., B. of Ae.E., Group Leader, Performance Group, Aerodynamics Sect., Douglas Aircraft Co., Inc. (El Segundo).

Smith, Randall C., B.S., Asst. Chief Engr., East Coast Aeronautics, Inc.

Elected to MEMBER Grade

Aurand, Harold L., B.S. Engrg., Proj. Engr., Allison Div., General Motors Corp.

Breier, Uri, Capt. (Pilot Instructor), El-Al, Israel Air Lines.

Brown, George G., Supvr., Inst. Elect. Maint., American Airlines, Inc (La-Guardia).

Collins, Bertram E., B.S.E.E., Proj. Liaison Sales Engr., Air Arm Div., Westinghouse Electric Corp.

Crump, Ralph E., B.Sc., Chief Engr., Electrofilm, Inc.

"Little David", a modern slingshot, provides instant action when seconds count... hurling a lethal Goliath-killer into the blue at the snap of a finger.

The "Little David" Catapult is RMI's answer to many launching problems. One of the newest developments of Reaction Motors, Inc. rocket power research, this superior device can be used for a wide variety of launching applications.

RMI, first American rocket engine company, has many other significant "Firsts" in powerplant development, and is a leader in the application of rocket power for... Aircraft Powerplants... Missile Boosters and Sustainers... Auxiliary Power Units... and many special related devices.

Spearheading Progress through Research

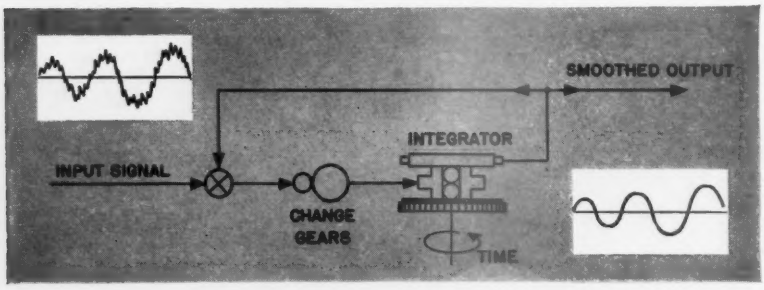
Career opportunities available for experienced mechanical, aeronautical, electrical and chemical engineers, physicists, chemists. Send complete resume to employment manager.

REACTION MOTORS, INC.
Denville, New Jersey
Affiliated with OLIN MATHIESON CHEMICAL CORP.

SINCE 1915 LEADERS IN AUTOMATIC CONTROL

Smoothing Signal Noise with the DBR* Integrator

Confronted with the well-known problem of random fluctuations called "noise," Ford engineers have employed the earliest and best-known Ford component – the disk integrator. Used in Ford analogue computers, the disk integrator smoothes random fluctuations due to extraneous influences and obtains an average of the received signal. Thus, a device originally designed by Ford for integration is successfully used as a mechanical counterpart of the RC Filter.



The Ford circuit operates on the premise that the older the data the less important it is. Therefore, data smoothed must be weighted in proportion to its age, so that the weight assigned to it decreases exponentially with time. The output of the circuit then represents the summation of this weighted data and tends to ignore random noises of short time duration.

As shown in the drawing, the incoming signal (with noise superimposed) is the input to the differential. As long as the integrator output (the roller) rotates at the *same rate* as the incoming signal, the differential output (error signal) is stationary and the integrator carriage remains stationary. But any change in the incoming signal produces changes in the *error signal* which tends to displace the integrator carriage and thus restore the system to equilibrium.

This reaction, however, is not instantaneous. It occurs after a certain time-lag which may be adjusted by the gear ratio. If the signal is of brief, random nature, the time-lag of the integrator will prevent its acting on the system. On the other hand, a permanent change in the signal will displace the carriage and change the output of the system.

This use of the Ford disk integrator as a noise smoother exemplifies the flexibility and adaptability of Ford components and ideas.

*Disk, Balls and Roller Integrator

68

FORD INSTRUMENT COMPANY
DIVISION OF SPERRY RAND CORPORATION
31-10 Thomson Avenue, Long Island City 1, N. Y.

ENGINEERS
of unusual abilities can find a future at FORD INSTRUMENT COMPANY. Write for information.

Daskin, Walter, M.S.E., Analysis Engr., AGT Div., General Electric Co. (Cincinnati).

Dow, Paul C., Jr., M.S.E. in Ae.E. & Instrumentation Engrg., Capt., USAF; Instructor, Aero. Engrg. Dept., USAF Institute of Technology, Wright-Patterson AFB.

Ference, Edward W., B.S. in C.E., Stress Analyst—Aircraft Struct., Machine & Tool Designing Corp.

Fischler, Jerome E., B.S.Ae.E., Design Specialist, Douglas Aircraft Co., Inc. (Long Beach).

Fourney, David R., B.S.M.E., Sales Engr., Sperry Gyroscope Co.

Freeman, William B., M.S.Ae.E., Tech. Dir., Systems R&D, Temco Aircraft Corp.

Freymuller, Frederick R., B.S., Sales Rep., Sperry Gyroscope Co.

Gardner, Robert W., B.S., Tech. Engr., Small Aircraft Engine Dept., General Electric Co. (West Lynn).

Gerves, Francis, Ing. des Arts & Manufactures, Design Engr., Lockheed Aircraft Corp. (Burbank).

Givens, Douglas J., Sales Rep. (Wash., D.C.), The de Havilland Aircraft of Canada Ltd.

Hamer, Harold A., B.S. in Ae.E., Aero. Research Scientist, NACA (Hampton).

Howard, A. W., M.S., Sales Engr., General Electric Co. (Wash., D.C.).

Jeffers, Frank G., A.A., Engrg. Designer "A," Northrop Aircraft Corp.

Lob, Werner, M.S., Staff Engr., Bendix Aviation Corp.

Kinnaman, W. A., B.S. in Engrg., Mgr.—Product Planning & Marketing Research, General Electric Co. (Johnson City).

MacCuish, Earl B., B.A.Sc. in Ae.E., Aerodynamics Engr., Lockheed Aircraft Co., Inc. (Burbank).

Meyer, Alvin F., Jr., B.S. Lt. Col., USAF; Chief, Preventive Medical Branch & Chief Engr. (Hqs. SAC Offutt AFB, Neb.), Office of the Surgeon.

Milliken, Samuel A., B.S., Dynamics Engr., Convair, San Diego, A Div. of General Dynamics Corp.

Pearson, Carl E., Ph.D., Asst. Prof.—Applied Mechanics, Harvard Univ.

Reeder, James P., Chief Inspector, A.C.F. Industries, Inc.

Schwoerer, Frank, M.S. (Marine Engrg.), Sect. Mgr.—Advanced Devel., AGT Div., Westinghouse Electric Corp.

Seliger, Rudolf R., M.E.E., Proj. Mgr.—Automatic Flight Control, Eclipse-Pioneer Div., Bendix Aviation Corp.

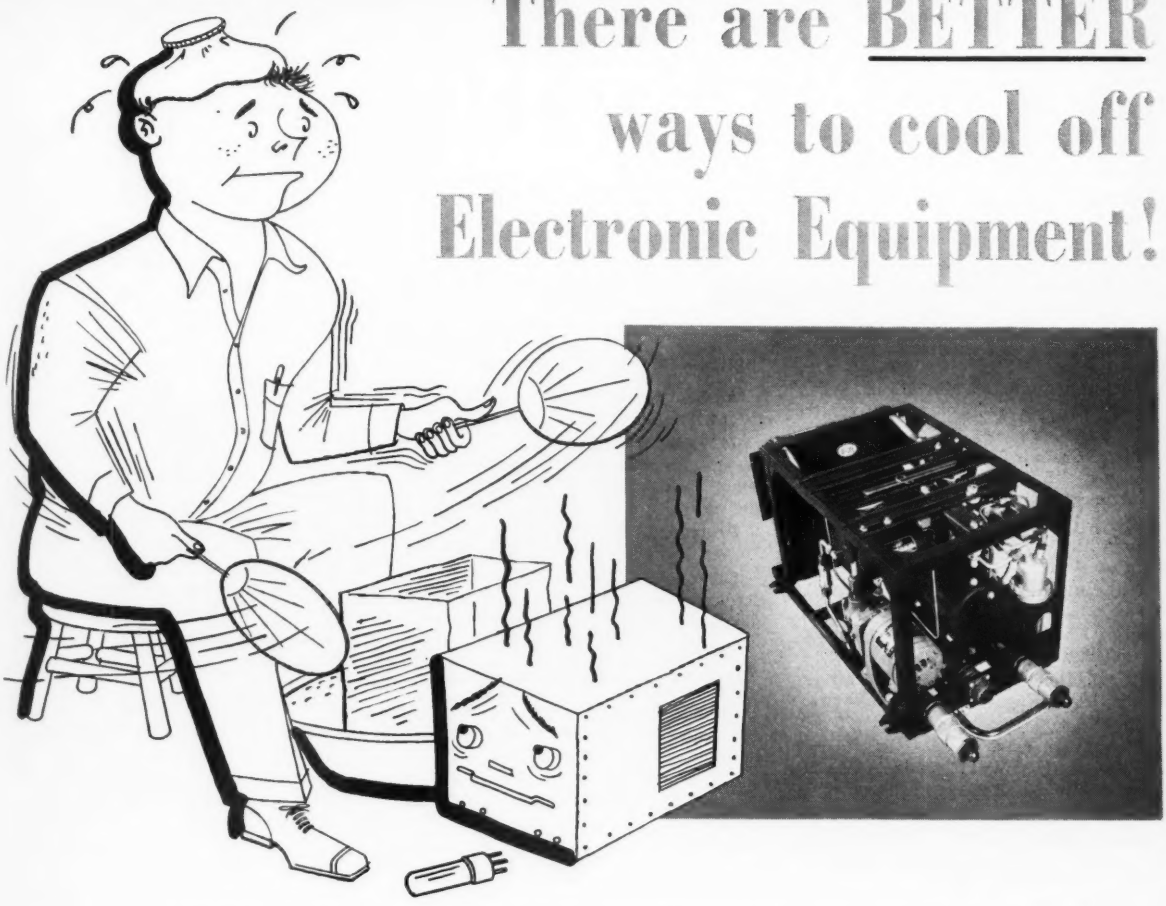
Shiokari, Tom, B.S. in Engrg., Struct. Engr. "A," R&D, Aerophysics Development Corp.

Slattery, T. B., B.S. General Engrg., Sr. Engr. (Acting Asst. Head, Environmental Dept., R&D Sect.), American Bosch-Arma Corp.

Taylor, John E., M.S.M.E., Assoc. Mgr., New Devices Dept., Staff R&D, Thompson Products, Inc.

Vandenberg, Cornelius E., M.S.E., Sr. Research Engr., Prelim. Design Group, Composite Analysis Group, North American Aviation, Inc. (Downey).

There are BETTER ways to cool off Electronic Equipment!



. . . . . and UAP has cooling systems in production. They are being manufactured to MIL-E-5400 and/or MIL-E-7272A, and they can be slightly modified to obtain performance characteristics other than contained in the original design specifications.

If these UAP Systems — now in production — cannot be modified to meet your requirements, UAP development engineers can tailor a heat-dissipation package to meet your specific needs to assure you minimum weight, minimum size, and lowest power consumption.

TWO TYPICAL SYSTEMS

The U-514744-1 system dissipates up to 3300 watts at 50,000 feet with power consumption of about 550 watts. Approximate dry weight: 37 lbs.

The U-515355-1 system dissipates up to 350 watts at 70,000 feet, consuming 75 watts (electrical) and 15 watts (air horse power). Approximate dry weight: 9 lbs.

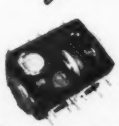
Check these "in-production" systems with your UAP contractual engineer before considering a completely new system.

UAP CONTRACTUAL ENGINEERING OFFICES:

Dayton, Ohio	MIchigan 3841
New York	Murray Hill 7-1283
North Hollywood, Calif.	STanley 7-7423
Montreal, Canada	ELwood 4131

a famous family of aircraft essentials

Heat Exchangers


Diverter Segregator Valves

Cold Weather System Hoppers

Oil Tanks

Fuel Control Valves

UAP — UNITED AIRCRAFT PRODUCTS, INC.

UNITED AIRCRAFT PRODUCTS, INC.

1116 BOLANDER AVENUE, DAYTON, OHIO

Walker, John P., Jr., M.S., Div. Chief—R&D, Haller, Raymond & Brown, Inc.

Whitcher, Lawrence G., Air Tech. Intelligence Specialist, Dept. of Air Force (ATIC), Wright-Patterson AFB.

Wijnholds, W. H. J., M.S. in M.E., Asst. to Executive V-P, KLM Royal Dutch Airlines (New York).

Wilde, Charles J., A.E., Chief Engr., Titeflex, Inc.

Yamron, Joseph, S.B., Research Engr., Instrumentation Lab., Massachusetts Institute of Technology.

Transferred to MEMBER Grade

Bachman, John A., Jr., B. of Ae.E., Aerodynamics Engr., Comprehensive Designers, Inc.

Bonk, Casimir J., B. of Ae.E., Engrg. Designer "B," Boeing Airplane Co. (Seattle).

Cady, Joseph G., B.S. in Ae.E., Instructor, Dept. Mechanical Engrg., Syracuse Univ.

Calhoun, John D., M.S.E. (Aero. Engrg.), Major, USAF; Asst. Prof.—Mechanical Engrg., USAF Institute of Technology, Wright-Patterson AFB.

Carroll, Donn M., B.S. in Ae.E., Power Plant Group Engr., Piasecki Helicopter Corp.

Diehl, Verner P., B. of Ae.E., Engrg. Designer "B," Wind Tunnel Model Design Group, Boeing Airplane Co. (Seattle).

Field, Albert F., B.S. Management (Industrial) Engrg., Asst. District Mgr., Walter Kidde & Co., Inc.

Gordon, James A., B. of Ae.E., Aerodynamics Engr., Member, Aeroanalysis Group, Aerodynamics Sect., Convair, Ft. Worth, A Div. of General Dynamics Corp.

Heydon, Douglas Allyn, B. of Ae.E., Engr., Sparrow Field Test Unit, NAMTC, Point Mugu.

Huss, Carl R., B.S. in Ae.E., Aerodynamics Loads Engr. III, NACA, Langley Field.

Mayer, John P., B.S.E. (Aero.), Aero. Research Scientist, Maneuver Loads Branch, Flight Research Div., Langley Aero. Lab., NACA.

Metz, Theodore R., B.S.M.E. (Aero.), Engr.—Flight Test, North American Aviation, Inc. (Downey).

Nordling, Tore, Civ. Ing., Proj. Engr., Royal Swedish Air Board (Stockholm).

Pursell, Lynn C., Jr., B.S. in Ae.E., Supvr., Aircraft Engrg. Sect., GS-11, Sacramento Air Material Area, Directorate, Maintenance-Engrg., Engrg. Div., USAF.

Voss, Herbert M., Sc.D., 1st Lt., USAF; Student, Pilot Training Program, Stallings AB.

Elected to Associate Member Grade

Anthony, James C., B.S. in Economics, Mgr., *Aviation Week* (New York).

McFarland, William C., Jr., Sales Engr.—Bomber Defense Systems, Arm Div., Westinghouse Electric Corp. (Baltimore).

Pearson, Lee M., B.S., General Engr., BuAer, Navy Dept. (Wash., D.C.).

Scherer, P. H., A.B., West Coast Regional Rep., Aeronca Manufacturing Corp.

Elected to Technical Member Grade

Cronin, Thomas J., Jr., B. of Ae.E., Jr. Engr. "A," Boeing Airplane Co. (Seattle).

Elk, Seymour B., B.Sc., Thermodynamic Missile Devel. Engr., McDonnell Aircraft Corp.

Meisel, Robert M., M.S., Mathematician, Republic Aviation Corp.

Transferred to Technical Member Grade

Bruce, Arthur C., B.S. in Ae.E.

Dunn, Walter P., B.S., Performance Group Engr., Douglas Aircraft Co., Inc. (El Segundo).

Elwell, Ralph A., B.S. in Ae.E., Jr. Scientist & Engr., Hill AFB.

Evert, Jack K., B.S. in Ae.E.

Haase, Gerhard, B.S. in Ae.E., Engr.—Design, Chrysler Corp.

Hancock, John I., Jr. Design Engr., North American Aviation, Inc. (Los Angeles).

Heist, E. Kenneth, S.M., Engr., Ramo-Wooldridge Corp.

Hodgson, Voigt R., B.S. in Ae.E.

Hughey, George H., M.S. (AE), Lt., USN; Officer in Charge, VC-4 Detachment, NAS (Atlantic City).

Lick, Wilbert James, B.S. in Ae.E.

Lombardo, Mario C., Struct. Engr., Grumman Aircraft Engineering Corp.

Martellucci, Anthony, B. of Ae.E., Research Asst., Polytechnic Institute of Brooklyn.

Martuccelli, John R., M.S., Sr. Engr., Aeroelastic Research Lab., Massachusetts Institute of Technology.

Matthews, Malcolm L., B.S. in Ae.E., Student & Chief Computer, Aero. Labs., Univ. of Washington (Seattle).

Mattson, Wayne O., B.S. in Engrg., 2nd Lt. & Student Officer, Aircraft Observer Training, USAF, Ellington AFB.

Melisaratos, James, Stress Analyst, The Glenn L. Martin Co.

Midgorden, John L., B.S., Jr. Engr., Chance Vought Aircraft, Inc.

Natalizio, Michael C., Jr. Design Engr., North American Aviation, Inc. (Columbus).

Ober, Leonard J., Tool Designer, Grumman Aircraft Engineering Corp.

Poucher, Donald D., B.S. in Ae.E., Jr. Engr., Chance Vought Aircraft, Inc.

Ransom, Leslie R., B.S. in Ae.E.

Rawlings, William L., B. of Ae.E., Engr., Propulsion & Aerodynamics Group, Northrop Aircraft, Inc.

Reaves, Glenn L., B.E., Engr.—Flight Test Data Analysis, North American Aviation, Inc. (Downey).

Shirley, Lowell R., B.S., Assoc. Engr., Douglas Aircraft Co., Inc. (El Segundo).

Speer, Blake D., Jr., B.S., Struct. Test Engr., Chance Vought Aircraft, Inc.

Warren, Edgar B., B. of M.E. (Aero.), Aero. Research Intern, NACA, Langley Field.

Wasicko, Richard J., B. of Ae.E., 1st Lt., USAF; Proj. Engr., Flight Controls Lab., WADC, Wright-Patterson AFB.

Changes of Address

Since the Post Office Department does not as a rule forward magazines to forwarding addresses, it is important that the Institute be notified of changes in address 30 days in advance of publishing date to ensure receipt of every issue of the *Journal* and *Review*.

Notices should be printed legibly and sent directly to the Institute of the Aeronautical Sciences, Inc., 2 East 64th Street, New York 21, N.Y.

Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

I. PERIODICALS AND REPORTS

Aerodynamics
- Boundary Layer ... 92
- Control Surfaces ... 92
- Fluid Mechanics & Aerodynamic Theory ... 92
- Internal Flow ... 92
- Performance ... 94
- Stability & Control ... 94
- Wings & Airfoils ... 94

Aeroelasticity ... 96
Aeronautics, General ... 97
Air Transportation ... 97
Airplane Design ... 97
- Control Systems ... 97
- Landing Gear ... 98
- Operation & Performance ... 98

Airports ... 98
- Traffic Control ... 98

Aviation Medicine ... 98
Computers ... 98
Education & Training ... 98
Electronics ... 98
- Amplifiers ... 100
- Antennas ... 100
- Capacitors ... 100
- Circuits & Components ... 100
- Communications ... 100
- Construction Techniques ... 102
- Dielectrics ... 102
- Electronic Controls ... 102
- Electronic Tubes ... 102
- Magnetic Devices ... 102
- Measurements & Testing ... 102
- Navigation Aids ... 102
- Networks ... 102
- Noise & Interference ... 102
- Oscillators & Signal Generators ... 102
- Radar ... 102
- Resistors ... 102
- Semiconductors ... 104
- Telemetry ... 104
- Transmission Lines ... 104
- Wave Propagation ... 104

Equipment
- Electric ... 104
- Hydraulic & Pneumatic ... 104

Flight Operating Problems
- Cruise Control & Piloting ... 104

Fuels & Lubricants ... 104
Gliders ... 104
Instruments ... 104
- Automatic Control ... 104
- Flight Instruments ... 104
- Flow Measuring Devices ... 106
- Pressure Measuring Devices ... 106
- Temperature Measuring Devices ... 106

Machine Elements
- Bearings ... 106
- Fastenings ... 108
- Friction ... 108
- Gears & Cams ... 108
- Mechanisms & Linkages ... 108
- Rotating Discs & Shafts ... 108
- Springs ... 108

Materials ... 108
- Corrosion & Protective Coatings ... 108
- Metals & Alloys ... 108
- Metals & Alloys, Nonferrous ... 108
- Nonmetallic Materials ... 108
- Sandwich Materials ... 108
- Testing ... 108

Mathematics ... 108
Mechanics ... 110
Meteorology ... 110
Military Aviation & Armament ... 110
Missiles ... 110
Navigation ... 110
Noise Reduction ... 110
Parachutes ... 110
Photography ... 110
Power Plants ... 112
- Jet & Turbine ... 112
- Reciprocating ... 114
- Rocket ... 114

Production
- Metalworking ... 114
- Nonmetalworking ... 114
- Production Engineering ... 114
- Tooling ... 114
- Welding ... 114

Propellers ... 116
Reference Works ... 116
Rotating Wing Aircraft ... 116
Safety ... 116
Space Travel ... 116
Structures ... 116
- Bars & Rods ... 116
- Cylinders & Shells ... 116
- Elasticity & Plasticity ... 116
- Plates ... 118
- Testing ... 118

Thermodynamics ... 118
- Combustion ... 119
- Heat Transfer ... 119

Vertical Take-Off Aircraft ... 119
Water-Borne Aircraft ... 119
Wind Tunnels & Research Facilities ... 119

II. BOOKS REVIEWED IN THIS ISSUE

The Dynamics and Thermodynamics of Compressible Fluid Flow, Vol. II. Ascher H. Shapiro ... 121

Reviewed by Harold L. Bloom, General Electric Company

Book Notes ... 124

Books, reports, and periodicals reviewed in this issue or in previous issues may be borrowed on 2-week loan without charge by individual or Corporate Members of the Institute in the U.S. and Canada; excepted are certain reference books and IAS publications which are available for purchase. Members of The Paul Kollsman Lending Library who are not members of the Institute may borrow books and, in special cases, other research material. Members of the IAS may borrow also from the Engineering Societies Library through The Paul Kollsman Lending Library.

Photostatic copies of material in the Institute's libraries may be obtained at a cost of $0.35 to members and Corporate Members ($0.45 to nonmembers) for each 8½- by 11-in. print and $0.40 to members and Corporate Members ($0.50 to nonmembers) for each 11½- by 14-in. print, plus postage. A minimum charge of $1.00 is made to nonmembers of the IAS.

Bibliographies on special subjects will be compiled at the rate of $2.50 per hour. *Translations* of technical literature from foreign languages may be obtained at $15 to $20 per 1,000 words, depending on the language.

Full information about library membership and facilities will be sent upon request to The Paul Kollsman Lending Library, 2 East 64th St., New York 21, N.Y.

Aerodynamics

Boundary Layer

The Behavior of the Boundary Layer in the Region of Transition from Laminar to Turbulent Flow. Jerome Persh. *J. Aero. Sci.*, June, 1955, pp. 443, 444.

Boundary Layer Control for High Lift and Low Drag. G. V. Lachmann. *Handley Page Bul.*, Spring, 1955, pp. 4–8. Survey of the problem; developments improving aircraft performance, economy, and safety; and potentialities in using airflow techniques.

Effect of a Discontinuity on Turbulent Boundary-Layer-Thickness Parameters with Application to Shock-Induced Separation. Eli Reshotko and Maurice Tucker. *U.S., NACA TN 3454*, May, 1955. 21 pp. 15 refs.

Longitudinal Turbulent Spectrum Survey of Boundary Layers in Adverse Pressure Gradients. Virgil A. Sandborn and Raymond J. Slogar. *U.S., NACA TN 3453*, May, 1955. 40 pp. 22 refs.

A Method of Quadrature for Calculation of the Laminar and Turbulent Boundary Layer in Case of Plane and Rotationally Symmetrical Flow. E. Truckenbrodt. (*Ingen.-Arch.*, No. 4, 1952, pp. 16–228.) *U.S., NACA TM 1379*, May, 1955. 40 pp. 19 refs. Translation.

Rozwiązanie Przybliżone Równania Warstwy Przyściennej Prandtla (An Approximate Solution of Prandtl Equation of Fluid Motion in the Boundary Layer). Piotr Szymański. *Arch. Mech. Stosowanej* (Warsaw), No. 7, 1955, pp. 34–51. In Polish, with summaries in English and Russian.

Separation of a Supersonic Turbulent Boundary Layer. S. M. Bogdonoff and C. E. Kepler. *J. Aero. Sci.*, June, 1955, pp. 414–424, 430. 21 refs. Experimental investigation at M = 3 of the separation under the effect of a strong adverse gradient by examining the phenomena of flow over a step and shock-wave boundary layer interaction; use of wall static pressures, total head surveys, and optical and schlieren techniques to provide a model of the phenomena.

Separation, Stability, and Other Properties of Compressible Laminar Boundary Layer with Pressure Gradient and Heat Transfer. Morris Morduchow and Richard G. Grape. *U.S., NACA TN 3296*, May, 1955. 45 pp. 20 refs.

Comparison of Effectiveness of Convection-Transpiration-, and Film-Cooling Methods with Air as Coolant. E. R. G. Eckert and John N. B. Livingood. (*U.S., NACA TN 3010*, 1954). *U.S., NACA Rep. 1182*, 1954. 17 pp. 12 refs. Supt. of Doc., Wash. $0.20. Evaluation of the relative merits of the aerodynamic cooling techniques, with comparative calculations for the case of a flat plate in laminar and turbulent flow at Reynolds Numbers between 10^3 and 10^9 and coolant-flow ratios between 0–0.012.

Heat Conducting Bodies in Boundary-Layer Flow. Salomon Levy. *J. Aero. Sci.*, June, 1955, pp. 440, 441.

Laminar Heat Transfer in Two-Dimensional Subsonic Effusors. Paul A. Libby and Marian Visich, Jr. *J. Aero. Sci.*, July, 1955, pp. 425–430. Method based on an extension of the von Kármán integral analysis used to solve the laminar boundary-layer equations for flows with axial pressure gradient and heat transfer.

Control Surfaces

Canted Adjustable End Plates for the Control of Drag. Harry R. Clements. *Aero. Eng. Rev.*, July, 1955, pp. 40–44. Theoretical principles and wind-tunnel experimental investigation of the CAEP control surfaces to improve take-off and landing performance.

Fluid Mechanics & Aerodynamic Theory

Aerodynamics. Max M. Munk. *Appl. Mech. Rev.*, June, 1955, pp. 221–223. A general retrospective and developmental review of fundamental fluid motion principles, their implications in technological advances, and potentialities of research and experimentation.

Mechanism of Cavitation Inception and the Related Scale-Effects Problem. R. W. Kermeen, J. T. McGraw, and B. R. Parkin. *Trans. ASME*, May, 1955, pp. 533–540; Discussion, pp. 540, 541. 20 refs. Navy-sponsored experimental investigation at the CIT High Speed Water Tunnel, with a review of previous researches.

Pressure Waves Generated by Addition of Heat in a Gaseous Medium. Boa-Teh Chu. *U.S., NACA TN 3411*, June, 1955. 47 pp. 10 refs. Analytical development of analogies between the pressure waves generated by heat release and those generated by mass release, piston motion, or a two-dimensional body in a supersonic stream to study dynamic shock effects such as found in detonation and compression time-dependent problems.

The Drag of Non-Planar Thickness Distributions in Supersonic Flow. Appendix I—Optimum Thickness Distribution for Elliptical Plan Form. Appendix II—Ring-Wing and Central Body of Revolution Combination Having Drag of Sears-Haack Body; Ring-Wing and Central Body of Revolution Having Zero Drag. E. W. Graham, B. J. Beane, and R. M. Licher. *Aero. Quart.*, May, 1955, pp. 99–113.

Simplified Calculations of Pressure Distribution on Unyawed Slender Bodies of Revolution in Hypersonic Flight. R. F. Probstein and K. N. C. Bray. *USAF WADC TR 54-258*, July, 1954. 12 pp. 19 refs.

Supersonic Flow Past Slender Bodies With Discontinuous Profile Slope. L. E. Fraenkel and H. Portnoy. *Aero. Quart.*, May, 1955, pp. 114–124.

Unsteady Plane Flow Past Curved Obstacles with Infinite Wakes. L. C. Woods. *Proc. Royal Soc. (London), Ser. A*, Apr. 21, 1955, pp. 152–180. 11 refs. Analytical development for the case when velocities and displacements of the unsteady perturbations about the mean steady motion are small; applications include stalled airfoil flutter problems.

Asymptotic Spherical Shock Decay. L. M. Tannenwald. *J. Appl. Phys.*, May, 1955, pp. 551–555. Derivation of an equation based on a quasi-stationary approximation for the problem of viscous and heat conductive effects relating shock strength and radius.

Blast Wave Calculation. Herman H. Goldstine and John von Neumann. *Comm. on Pure & Appl.-Math.*, May, 1955, pp. 327–353. Analysis of the decay and propagation of the shock wave generated by a very strong point-source explosion in an ideal gas under the assumption of spherical symmetry and of the behavior of the pressure as a function of radial distance for fixed times and as a function of time for fixed distances.

A Model for One-dimensional Compressible Turbulence with two Sets of Characteristics. I, II. J. M. Burgers. *Netherlands, Koninklijke Nederlandse Akademie van Wetenschappen, Proc. Ser. B*, No. 1, 1955, pp. 1–18. Reprint.

Statistical Problems Connected with the Solution of a Simple Non-Linear Partial Differential Equation—Continuation. I, II, III. J. M. Burgers. *Netherlands, Koninklijke Nederlandse Akademie van Wetenschappen, Proc. Ser. B*, No. 4, 1954, pp. 403–433. Reprint. Application of the solutions of the equation

$$\frac{\partial v}{\partial t} + v\frac{\partial v}{\partial y} = \nu\frac{\partial^2 v}{\partial y^2}$$

as the simplest analog of the hydrodynamic equations to the investigation of turbulence of fluid motion.

Internal Flow

Compressor Surge and Stall Propagation. H. W. Emmons, C. E. Pearson, and H. P. Grant. *Trans. ASME*, May, 1955, pp. 455–467; Discussion, pp. 467–469. Experimental investigation using hot-wire anemometer instrumentation to develop a theoretical analysis of the unstable flow characteristics, distinguishing between surge and flow fluctuations due to stall propagation.

Luftkräfte an einem schwingenden Gitter. H. Söhngen. *ZAMM*, Mar., 1955, pp. 81–88. In German. Investigation of the nonstationary aerodynamic forces for an unstaggered cascade, with the blades vibrating in the same phase in a stream parallel to the blades.

A Note on Simplified Single Spool Turbojet Equilibrium Operation. Charles A. MacGregor. *J. Aero. Sci.*, June, 1955, pp. 431, 432. Determination of the compressor corrected airflow-r.p.m. characteristics to permit a certain constant r.p.m., constant combustion temperature, and constant jet nozzle area operation.

Tests Related to the Effect of Profile Shape and Camber-Line on Compressor Cascade Performance. S. J. Andrews. *Gt. Brit., ARC R&M 2743* (Oct., 1949), 1955. 23 pp. BIS, New York. $1.50.

Theoretical Analysis of Incompressible Flow Through a Radial-Inlet Centrifugal Impeller at Various Weight Flows. I—Solution by a Matrix Method and Comparison with an Approximate Method. Vasily D. Prian, James J. Kramer, and Chung-Hua Wu. **II—Solution in Leading-Edge Region by Relaxation Methods.** James J. Kramer. *U.S., NACA TN 3448, TN 3449*, June, 1955. 39, 19 pp. 21 refs.

Untersuchungen an Schaufelgittern von Strömungsmaschinen. Norbert Scholz. *ZFW*, Mar.–Apr., 1955, pp. 99–104. In German. Theoretical and experimental investigations of cascade flows to improve aerodynamic effectiveness of turbomachines.

Every pound of equipment weight saved is worth its weight in gold!

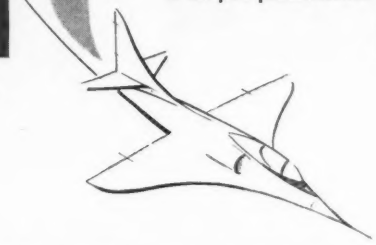
(THIS IS A FACT . . . THIS IS NO HYPERBOLE)

E. H. HEINEMANN
Chief Engineer, El Segundo Division
Douglas Aircraft Company, Inc.

"It is extremely important that designer, equipment manufacturers, and procuring agencies all have a clear understanding of the relationship between weight-saving and manufacturing costs. While the factor that relates cost to weight varies somewhat for different components and from one manufacturer to another, it has been found in recent years that on the average a pound of weight costs $50 to develop and produce. When this factor is combined with a typical weight growth factor of ten, *the cost of one pound of extra weight amounts to $500 per airplane if performance and strength are to be maintained.* From these figures it can be seen that there is ample justification for the expenditure of engineering time on all phases of a weight-saving program, no matter how small the individual saving may seem."

—E. H. HEINEMANN

at SAE National Aeronautic Meeting, Los Angeles



This growth factor discussed by Mr. Heinemann makes excess weight costly indeed. At $500 per pound, it literally costs its weight in gold. (Gold at $35 per troy ounce is worth $510.30 per avoirdupois pound.)

Vickers Hydraulic Accessories are used extensively in Douglas aircraft because Vickers has long been keenly conscious of the need for lighter, highly efficient and more dependable components. Vickers engineering strives continuously for these goals . . . is a leader in the reduction of weight, and the improvement of performance and reliability of hydraulic equipment. For detailed engineering attention to your problem call a Vickers Application office or write for Bulletin A5200B.

7150

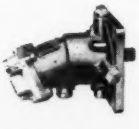
VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
1414 OAKMAN BLVD. • DETROIT 32, MICH.

Application Engineering and Service Offices:
El Segundo, California, 2160 E. Imperial Highway (ORegon 8-2503)
Arlington, Texas, P.O. Box 213 (ARlington 4-4171)
Detroit 32, Michigan, 1400 Oakman Blvd. (TOwnsend 8-5100)
Additional Service facilities at:
Miami Springs, Florida, 641 De Soto Drive (Phone 88-7340)

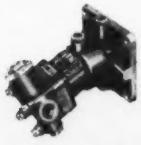
TELEGRAMS: Vickers WUX Detroit • TELETYPE "TWX" DE89
CABLE: Videt Detroit

Representative VICKERS® "Weight Saving" Equipment

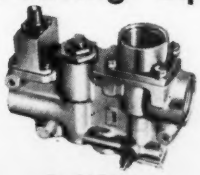
Variable Displacement Piston Type Pump



Constant Displacement Piston Type Pump



Constant Speed Piston Type Motor



Special 5-in-1 Pump Control Valve

Flow Sensitive Pressure Regulator

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Analysis of Fully Developed Turbulent Heat Transfer and Flow in an Annulus with Various Eccentricities. Robert G. Deissler and Maynard F. Taylor. *U.S., NACA TN 3451*, May, 1955. 42 pp. 11 refs.

Low-Speed Investigation of the Effects of Angle of Attack on the Pressure Recovery of a Circular Nose Inlet with Several Lip Shapes. James R. Blackaby. *U.S., NACA TN 3394*, May, 1955. 30 pp.

A Preliminary Investigation of Aerodynamic Characteristics of Small Inclined Air Outlets at Transonic Mach Numbers. Paul E. Dewey. (*U.S., NACA RM L53C10*, 1953.) *U.S., NACA TN 3442*, May, 1955. 21 pp.

The Secondary Flow in Curved Pipes. H. G. Cuming. *Gt. Brit., ARC R&M 2880* (Feb., 1952), 1955. 17 pp. 10 refs. BIS, New York. $1.25. Solution of the Navier-Stokes equations for the flow of a viscous incompressible fluid through curved pipes of different sections.

Wave-Action in Gases: The Attenuation and Reflection of Compression Waves Propagated in Pipes. I, II. Appendix—Discharge from a Cylinder into a Pipe of the Same Bore Through a Constriction. G. F. Mucklow and A. J. Wilson. *IME Proc.*, No. 1, 1955, pp. 69–80; Communications, pp. 81, 82.

Applications of the Characteristic Method to the Supersonic Jet with Axial Symmetry. Akira Takano. *J. Japan Soc. Aero. Eng.*, Feb.-Mar., 1955, pp. 7-12. Numerical and graphical solution of the flow problem involving the envelope of the compression waves.

Comparison of Mixing Processes in Subsonic Jet Pumps. Heinrich B. Helmbold. *J. Aero. Sci.*, June, 1955, pp. 435-437. ONR-sponsored study.

On the Flow of a Compressible Fluid Through Orifices. D. A. Jobson. *Chartered Mech. Engr.*, May, 1955, pp. 257-259. Abridged.

The Performance of a Type of Swirl Atomizer. A. Radcliffe. *IME Proc.*, No. 3, 1955, pp. 93-100; Communications, pp. 101-106. NGTE investigation of optimum designs and shapes in terms of fundamental flow parameters.

Performance

Mach Zero. R. Cox Abel. *Aeronautics*, June, 1955, pp. 68–70. Review of the Aerodynamic take-off and landing speed problem of briefly supporting an aircraft in the air through the lower Mach speed range down to zero, with references to VTO and erector designs.

Stability & Control

A Simplified Treatment of Partial Fractions for Dynamic-Response Calculations. George S. Campbell. *J. Aero. Sci.*, June, 1955, pp. 437, 438.

La Stabilité Transversale de Vol et Quelques Recherches de l'O.N.E.R.A. Maurice Roy. *Tech. et Sci. Aeronautiques*, No. 5, 1954, pp. 305–320. In French. ONERA investigations of tests and experimental methods of analysis and synthesis to study aircraft rolling and stability problems.

A Technique Utilizing Rocket-Propelled Test Vehicles for the Measurement of the Damping in Roll of Sting-Mounted Models and Some Initial Results for Delta and Unswept Tapered Wings. William M. Bland Jr., and Carl A. Sandahl. (*U.S., NACA RM L50D24*, 1950.) *U.S., NACA TN 3314*, May, 1955. 25 pp.

Theoretical Investigation of a Proportional-Plus-Flicker Automatic Pilot. Appendix A—Determination of the Relation Which Expresses n/δ as a Function of Static Margin. Ernest C. Seaberg. (*U.S. NACA RM L50I19*, 1950.) *U.S., NACA TN 3427*, May, 1955. 53 pp. Analysis of the automatic pitch stabilization of a supersonic pilotless canard airframe, with a calculation of the transient responses based on the variation of the autopilot and aerodynamic parameters and on a simplifying assumption.

Wings & Airfoils

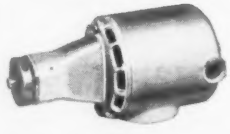
Aerodynamic Characteristics of Several 6-Percent-Thick Airfoils at Angles of Attack from 0° to 20° at High Subsonic Speeds. Bernard N. Daley and Douglas R. Lord. (*U.S., NACA RM L9E19*, 1949). *U.S., NACA TN 3424*, May, 1955. 57 pp.

The Calculation of Pressure on Slender Airplanes in Subsonic and Supersonic Flow. Max. A. Heaslet and Harvard Lomax. (*U.S., NACA TN 2900*, 1953.) *U.S., NACA Rep. 1185*, 1954. 11 pp. 16 refs. Prediction of pressure distribution about a wing, body, or wing-body configuration.

This motor is representative of the many *specially engineered* Lamb Electric Motors that are giving excellent service in a wide range of products.

The reliability of Lamb Electric Motors results from proper design and careful manufacture, by personnel having many years of experience in the small motor field.

Use of a Lamb Electric Motor frequently results in an improved product and lower costs. May we demonstrate these advantages to you?



Motor for high-speed grinder.

Aircraft fuel tank valve actuator.

THE LAMB ELECTRIC COMPANY
KENT, OHIO

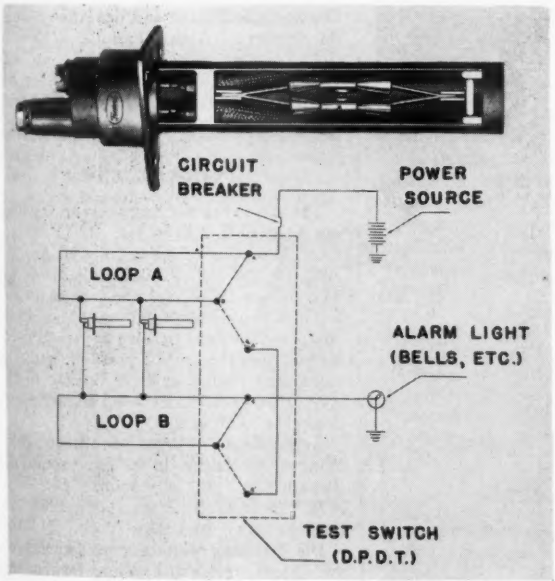
In Canada: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ontario

Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Why intercontinental and transcontinental aircraft depend on Fenwal unit detectors

1. **PROVED DEPENDABILITY** for America's first intercontinental bomber. Boeing's B-52 jet engine Stratofortress uses Fenwal Fire and Over-Heat Detectors for fire detection dependability and extra safety. Fenwal units accurately reset following actuation. These *long service* Fenwal detector units are tamper-proof and dust-proof, compact and easy to install.

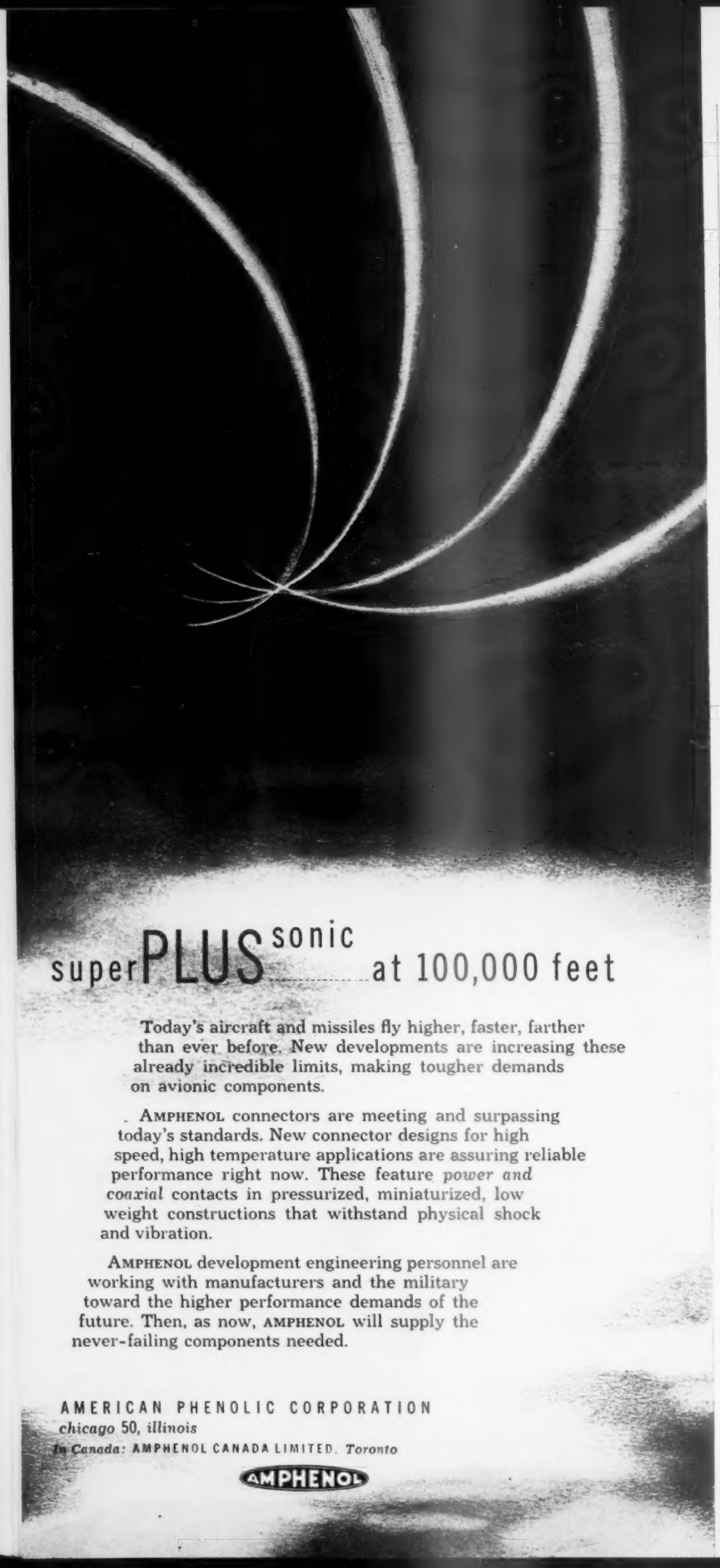
2. **EASY INSTALLATION.** Shown in Lockheed's transcontinental Super Constellation, these Fenwal unit Fire and Over-Heat Detectors are precision-set at the factory. Fenwal unit detectors eliminate the need for external relays, costly field adjustment and periodic maintenance. Fenwal units are in to stay — and stay right.



3. **COMPLETE FLEXIBILITY** for all types of aircraft. Fenwal units *anticipate* danger and give warning *before* emergencies occur. A single unit reacting will sound an alarm. Double loop circuitry guards against system failures, and gives duel push button operational check. Fenwal unit detectors meet exacting government and military specifications.

4. **GET FULL DATA** on Fenwal's *positive* Fire and Over-Heat Detectors, Heater Controls, Aircraft Gas Turbine Thermocouples and Accessory Controls. Fenwal manufactures precision devices for the entire aviation industry. Fenwal engineers can help solve *your* detection and control problem. Write to **Fenwal Incorporated, Aviation Products Division, 178 Pleasant Street, Ashland, Mass.**

Fenwal Controls Temperature . . . *Precisely*


super PLUS sonic
at 100,000 feet
Today's aircraft and missiles fly higher, faster, farther than ever before. New developments are increasing these already incredible limits, making tougher demands on avionic components.
AMPHENOL connectors are meeting and surpassing today's standards. New connector designs for high speed, high temperature applications are assuring reliable performance right now. These feature power and coaxial contacts in pressurized, miniaturized, low weight constructions that withstand physical shock and vibration.
AMPHENOL development engineering personnel are working with manufacturers and the military toward the higher performance demands of the future. Then, as now, AMPHENOL will supply the never-failing components needed.
AMERICAN PHENOLIC CORPORATION
chicago 50, illinois
In Canada: AMPHENOL CANADA LIMITED, Toronto
AMPHENOL

The Calculation of the Wave Drag of an Arbitrary Slender Body by Means of an Electrical Analogy Tank. P. J. Pocock. (*CAI 1st Annual Meeting Toronto, May 19, 20, 1955, Preprint.*) *Canada, NAE LR-127*, Mar. 17, 1955. 34 pp. 15 refs.

The Effects of Transonic Speeds of Thickening the Trailing Edge of a Wing with a 4-Percent-Thick Circular-Arc Airfoil. Joseph W. Cleary and George L. Stevens. *U.S., NACA RM A51J11*, Dec. 11, 1951. 43 pp.

Lift and Lift Distribution of Wings in Combination with Slender Bodies of Revolution. H. J. Luckert. *CAI 1st Annual Meeting, Toronto, May 20, 1955, Preprint.* 46 pp. 12 refs.

The Lift of Twisted and Cambered Wings in Supersonic Flow. G. N. Lance. *Aero. Quart.*, May, 1955, pp. 149–163. Use of a generalized conical flow theory to deduce an integral equation relating the velocity potential on a delta wing with subsonic leading edges to the given downwash distribution over the wing.

Notes on the Variation of Drag with Mach Number of a Busemann Biplane. B. J. Beane. *Douglas Rep. SM-18737*, Jan., 1955. 6 pp.

Optimum Two-Dimensional Multiplanes in Supersonic Flow. R. M. Licher. *Douglas Rep. SM-18688*, Jan., 1955. 23 pp. Use of linear theory to determine optimum configurations and distributions of camber and thickness for minimum drag due to lift.

A Study of Interference and Lift Transfer for a Staggered Delta-Wing Biplane in Supersonic Flow. B. J. Beane. *Douglas Rep. SM-18738*, Jan., 1955. 15 pp.

Sur l'Application de la Théorie Linéaire des Surfaces Portantes à des Ailes Munies de Spoilers. André Fauquet. *Tech. et Sci. Aéronautiques*, No. 6, 1954, pp. 428, 429. In French. Application of the linear theory of lifting surfaces to wings with spoilers.

Aeroelasticity

The Aerodynamic Forces on an Oscillating Aerofoil in a Free Jet. L. C. Woods. *Proc. Royal Soc. (London), Ser. A*, Apr. 21, 1955, pp. 235–250. Analysis based on the Theodorsen theory for the case of an airfoil in a two-dimensional jet of inviscid incompressible fluid performing small oscillations about its mean position, with the calculated results applied directly to the correction of open-jet wind-tunnel measurements on airfoils.

Aerodynamic Forces on Rectangular Wings Oscillating in a Supersonic Air Stream. W. E. A. Acum. *Gt. Brit., ARC R&M 2763* (Aug., 1950), 1954. 28 pp. 14 refs. BIS, New York. $1.70.

Die Erregung reiner Eigenschwingungen von Flugzeugflügeln; Eine Anwendung der Theorie der Integralgleichungen. Ernst Schultze. *ZAMP*, Mar. 25, 1955, pp. 126–135. In German. Theoretical analysis using the linear integral method of the steady-state response of airplane wings due to externally applied sinusoidal shaker forces accounting for damping, with the emphasis on the problem of exciting pure natural modes.

On the Calculation of the 1.P Oscillating Aerodynamic Loads on Single-Rotation Propellers in Pitch on Tractor Airplanes.

Vernon L. Rogallo and Paul F. Yaggy. *U.S., NACA TN 3395*, May, 1955. 28 pp.

On the Kernel Function of the Integral Equation Relating Lift and Downwash Distributions of Oscillating Wings in Supersonic Flow. Appendix A—Reduction of Kernel Function to Sonic Case. Appendix B—Derivation of Downwash Functions Associated with "Horseshoe" Vortices in Supersonic Flow. Charles E. Watkins and Julian H. Berman. *U.S., NACA TN 3438*, May, 1955. 43 pp. 19 refs.

On the Possibility of Aerolastic Reversal of Propeller Blades. F. W. Niedenfuhr. *J. Aero. Sci.*, June, 1955, pp. 438–440. USAF WADC-supported research at Ohio State U.

Some Calculations of the Lateral Response of Two Airplanes to Atmospheric Turbulence with Relation to the Lateral Snaking Problem. John D. Bird. (*U.S., NACA RM L50F26a*, 1950.) *U.S., NACA TN 3425*, May, 1955. 24 pp.

Some Effects of Mechanical Damping on the Self-Induced Aeroelastic Oscillations of an Axial Compressor Blade. Appendix I—Solution of the Equation of Motion. Appendix II—Numerical Solution for the Limiting Example. I. M. Davidson. *Aero. Quart.*, May, 1955, pp. 81–98.

Total Lift and Pitching Moment on Thin Arrowhead Wings Oscillating in Supersonic Potential Flow. H. J. Cunningham. *U.S., NACA TN 3433*, May, 1955. 43 pp.

On the Stability of the Equilibrium of a Linear Mechanical System. Oene Bottema. *ZAMP*, Mar. 25, 1955, pp. 97–104. Analysis of the general linear dynamical system with two degrees of freedom.

On Traveling Waves in Beams. Robert W. Leonard and Bernard Budiansky. (*U.S., NACA TN 2874*, 1953.) *U.S., NACA Rep. 1173*, 1954. 27 pp. 18 refs. Supt. of Doc., Wash. $0.30. Theoretical analysis of transient loadings of uniform beams of finite length based on the Timoshenko equations for the motion of vibrating nonuniform beams.

Problems of the Stability and Free Vibrations of a Cylindrical Shell. W. Nowacki. *Bul. Acad. Polonaise Sci.* (Warsaw), No. 1, 1955, pp. 11–15. Analogous solution of the vibration problem for the case of a shell supported at the edges and subjected to bending and compression.

Shock Isolation. Walter W. Soroka. *Prod. Eng.*, June, 1955, pp. 167–171. Method of analyzing displacement and inertia loads of an elastically mounted structure under impact, with the nondimensional analysis based on a half-sine-wave pulse.

Stability of Rectilinear Plates. B. R. Seth. *ZAMM*, Mar., 1955, pp. 96–99. Analysis of the critical thrust for the stability of a simply supported rectilinear plate under the combined action of transverse loads and edge thrusts in terms of the least eigenvalue for the transverse vibrations of a clamped membrane having the same boundary as the plate.

Aeronautics, General

The Influence on Civil Aviation of some Current Researches. (The 13th Brancker Memorial Lecture.) Arnold Hall. *J. Inst. Transp.*, May, 1955, pp. 101–118. Developmental and long-term appraisal of problems and prime aspects, including operational range characteristics, supersonic designs, take-off and landing improvements, reduction of the aerodynamic resistance to motion, limitations of structures and materials such as fatigue, destructive noise levels, bad-weather navigation, communication, and automatic guidance, and economic factors all related to safety, reliability, and practical requirements.

Research and Development Technical Planning Handbook. *Av. Age*, June, 1955. 376 pp. Features include: Cost parameters of a weapon system; missile experimentation; aerodynamics and fluid mechanics; aircraft designs, including fixed-wing, rotary-wing, and water-based types; aircraft guidance, traffic control, and instrumentation; electronic, pneumatic, hydraulic, electro-mechanical, refrigeration, and air conditioning accessory systems; metals, alloys, and nonmetallic materials; production engineering; test-training research equipment, including computers and simulators; list of prime contractors; and airport, heliport, and aviation operations.

Air Transportation

Air Cargo Shock Damage Experience in Handling and Shipping. A. C. Botsford. *SAE Golden Anniv. Aeronautic Meeting, New York, Apr. 18–21, 1955, Preprint 494.* 13 pp.

Antriebsfragen der Verkehrsluftfahrt von morgen. Otto Lutz. *ZFW*, Mar.–Apr., 1955, pp. 61–73. In German. Developmental and analytical survey of problems, trends, and potentialities in commercial aviation with the utilization of turboprop and jet propulsion for long-distance services.

Interchange Service Among the Airlines of the United States. Donald C. Winkelhake. *J. Air Law & Commerce*, Winter, 1955, pp. 1–50. 126 refs.

Über die Transportarbeit von Verkehrsflugzeugen. Hellmut Herb. *ZFW*, Mar.–Apr., 1955, pp. 74–79. In German. Analysis of the actual and potential range of commercial aircraft in terms of pay-load criteria based on the effects of specific fuel consumption, reserve fuel quantities, aerodynamic efficiency, freight versus passenger traffic, and on the fundamental aspects of design and propulsion.

Airplane Design

Aerodynamische Regeln für den Einbau von Strahltriebwerksgondeln. Gerhard Schulz. *ZFW*, May, 1955, pp. 119–129. 10 refs. In German. Design problems and criteria in positioning and attaching engine nacelles in aircraft to obtain the maximum aerodynamic efficiency in terms of lift and drag factors, with experimental data on the effect of each of the design parameters investigated separately and in combination with secondary parameters.

Aircraft Design and Mission Compatibility. Frederick M. Gloeckler. *Aero. Eng. Rev.*, July, 1955, pp. 28–31. Evaluation of basic requirements for an effective transport design in terms of group performance in an operational environment and of the findings of practical operations analysis techniques.

The Case for T-Tails. Hans Multhopp. *Aero Dig.*, May, 1955, pp. 32–35. Elements of superior design in the T-tail configuration, with an appraisal of the factors of aerodynamic interference, stability, downwash, and fin effectiveness.

Characteristics of Today's Family of Turboprops. H. W. Campen. *Aero Dig.*, May, 1955, pp. 23–29. Relative merits of the single-shaft, free-turbine, and dual-rotor design configurations, with modifications; comparison of ratings of performance and power plant efficiency between turboprops and turbojets.

Conférence sur la Mise au Point des Avions Bréguet "Deux-Ponts." G. Ricard. *Tech. et Sci. Aéronautiques*, No. 5, 1954, pp. 321–346. In French. AFITA Conference on the progress and development of the Bréguet Twin-Deck aircraft of the 761 and 763 series; analyses include design, aerodynamic, and aeroelastic characteristics of the different models.

The First Constellation Decade. Hall L. Hibbard and Clarence L. Johnson. *SAE Golden Anniv. Aeronautic Meeting, New York, Apr. 18–21, 1955, Preprint 506.* 17 pp. Developmental review of design improvements for the Lockheed transport.

Fokker F.27 Friendship; Holland's Up-and-coming Feedliner: Basic Simplicity Plus some New Techniques. *Flight*, June 3, 1955, pp. 762–767, 773, cutaway drawing. Design, development, structural, and operational characteristics.

France's Twin-jet Air Liner. James Hay Stevens. *The Aeroplane*, May 13, 1955, pp. 629–633. Design, structural, and performance characteristics of the SNCASE SE-210 Caravelle, with detailed diagrammatic descriptions of the servodyne, undercarriage, fuel, and artificial feel systems.

Mise au Point du Nord 2501. Calvy. *Tech. et Sci. Aéronautiques*, No. 5, 1954, pp. 363–370. In French. Design, development, structural, and performance characteristics.

The S.N.C.A.S.E. S.E.210 Caravelle; France's First Jet Airliner. I, II—Jet-Airliner Systems: Electrics, Hydraulics, Air Conditioning, Pressurization and Fuel Supply. *Flight*, May 20, 27, 1955, pp. 689–694; 734–738, cutaway drawing.

The Vickers' Viscount on Trans-Canada Air Lines' Routes. J. T. Dyment. *SAE Golden Anniv. Aeronautic Meeting, New York, Apr. 18–21, 1955, Preprint 505.* 23 pp. Details, including 27 illustrations, of design, structural, and performance characteristics, with emphasis on special features differing from the majority of American aircraft.

Control Systems

Fundamentals of Design of Piloted Aircraft Flight Control Systems. I—Method of Analysis and Synthesis. Chapter 5. D. T. McRuer and C. L. Bates. *U.S., NavBuAer Rep. AE-61-4*, 1954. 68 pp. 14 refs.

Powered Control Systems. R. Westbury. *Aeronautics*, June, 1955, pp. 54–59. Survey of the relative merits of control techniques, including the Hobson "Q feel" system, in terms of design require-

ments, operational characteristics, and effectiveness.

Landing Gear

Simplified Design Procedure for Utility Aircraft Spring Landing Gears. Ken S. Coward. *Aero Dig.*, May, 1955, pp. 48, 50, 52. Development of an analytical and graphical method.

The Undercarriage and Hydraulic System of the Bristol Britannia. British Messier, Ltd. *J. SLAE*, May, 1955, pp. 4–9. Design, operational, and structural details.

Operation & Performance

Flying the Fokker Mach-Trainer. John Fricker. *The Aeroplane*, Apr. 29, 1955, pp. 568–571. Detailed performance data.

The Long Range Transport Aeroplane. Peter Berry. *Aeronautics*, June, 1955, pp. 71–74, 79, 80. Descriptive and developmental appraisal of the performance ratings of the Super Constellation and DC-7 under particular operational conditions.

Airports

Light-Beacons to Aid Landing Aircraft. J. B. de Boer. *Philips Tech. Rev.*, Apr., 1955, pp. 273–286. Study of modern design, construction, configurational, and other requirements of airport lighting systems to meet diverse meteorological, navigational, and operational conditions.

Traffic Control

Hazards of VFR Flying in High-Density Areas. Sheldon E. Pangburn, Moderator, and others. *Skyways*, May, 1955, pp. 14–17, 32, 35–39, 44. Flight Operations Round Table discussion.

Aviation Medicine

Aero-Medical Aspects of High Altitude and High Velocity Flying. M. K. Mookerjee. *Indian AF Quart.*, Jan., 1955, pp. 33–46. 17 refs.

Color Signal Systems for the Red-Green Color Blind; An Experimental Test of the Three-Color Signal System Proposed by Judd. Louise L. Sloan and Adelaide Habel. *USAF SAM Project Rep. 55-20*, Feb., 1955. 8 pp.

Formation Lights for Fighter Aircraft. Charles A. Baker. *USAF WADC TR 55-124*, Mar., 1955. 15 pp. 15 refs. Application of the findings of USAF human engineering and psychological studies to improve design of wing-tip and other navigational lighting.

The Human Engineering of Aircraft Instruments and Controls. Robert E. Nethercut. *CAI 1st Annual Meeting, Toronto, May 19, 20, 1955, Preprint.* 12 pp.

Human Problems in Jet Air Transportation. Ross A. McFarland. *SAE Golden Anniv. Aeronautic Meeting, New York, Apr. 18–21, 1955, Preprint 504.* 28 pp. 50 refs. Review of prime factors related to operational safety and comfort in high-speed and high-altitude flight, including noise, vibration, accidental injuries, decompression and pressurization, visual perception and illusions, and fatigue.

The Influence of Drugs, Motivation, and Job Design Upon Work Decrement. Robert B. Payne and George T. Hauty. *USAF SAM Project Rep. 55-16*, Jan., 1955. 12 pp. 27 refs.

Review of Biological Effects of Subgravity and Weightlessness. David G. Simons. *Jet Propulsion*, May, 1955, pp. 209–211. 16 refs. Physiological and psychological problems of disorientation and discoordination affecting human responses in space.

Space Equivalent Conditions Within the Earth's Atmosphere—Physiological Aspects. H. Strughold. *Astronautica Acta*, Fasc. 1, 1955, pp. 32–40. 25 refs.

Human Centrifuge. *The Engr.*, May 27, 1955, pp. 732–735. Design and installation of a whirling beam at the RAF Inst. of Med. for research in physiological phenomenon under centripetal loading conditions.

Measurements to Evaluate the Effectiveness of the Full Pressure Half Suit in Applying External Pressure to the Body. Edward L. Beckman, O. L. Slaughter, and Earl H. Wood. *U.S., NADC Rep. NADC-MA-5502*, Mar. 21, 1955. 32 pp. Aviation Medical Acceleration Lab., Johnsville, Pa., research.

Psychiatric Screening of Flying Personnel; Research on the Personal Inventory Test. David K. Trites. *USAF SAM Project 21-0202-0007 Rep. 8*, Nov., 1954. 13 pp. 12 refs.

Studies in Abstractive Generalization; Comparison Between Performance of the Macaque and the Human Adult on the Same Problem. George Gentry, Sylvan J. Kaplan, and Ira Iscoe. *USAF SAM Project 21-3501-003 Rep. 12*, Nov., 1954. 8 pp. 20 refs.

Studies on Gas Exchange Applicable to Flying Personnel. III—The Maximal Diffusing Capacity of the Lungs. IV—The Maximal Diffusing Capacity of the Lung in Normal Male Subjects of Different Ages. R. L. Riley, R. H. Shepard, J. E. Cohn, D. G. Carroll, and B. W. Armstrong. *USAF SAM Project 21-1201-0014 Reps. 3, 4*, Sept., 1954. 15, 8 pp. 30 refs.

Computers

Automatic Intelligence Gathering Systems. Robert K. Stern. *ISA J.*, May, 1955, pp. 154–158. Design and operational principles of the Automatic Logger for processing analog and digital data.

Les Calculatrices Numériques Universelles. F. H. Raymond. *Tech. et Sci. Aéronautiques*, No. 6, 1954, pp. 373–388. In French. Basic design and operational principles of universal automatic numerical computers, with coding, programming, and sequential procedures outlined.

Computers at Oak Ridge. Earl W. Burdette. *ISA J.*, Feb., 1955, pp. 42–44. Analog and digital types applied to the design and development of simulators, data-handling, and other automatic devices for scientific purposes.

Electrical Analog Computing Machine for Solving Linear Equations and Related Problems. Samarendra Kumar Mitra. *Rev. Sci. Instr.*, May, 1955, pp. 453–457. Operational principles and design based on an iteration method whose convergence is dependent on a single predeterminable scalar parameter.

Electronic Data-processing Machines. George Truman Hunter and Graham M. Clark. *Instruments & Automation*, May, 1955, pp. 782–793. Fundamental design, operational, and other factors for different types of automatic computers; applications.

Exposé Pratique Relatif à l'Utilisation d'un Opérateur Mathématique Électronique au Groupe Technique de Cannes. Escursan. *Tech. et Sci. Aéronautiques*, No. 6, 1954, pp. 414–425. In French. Utilization at Cannes of the OME 111 computer to study such practical problems as the characteristics and adaptation of automatic pilots, with an appraisal of potentialities.

High Speed Computers. R. W. Thomas. *ISA J.*, Mar., 1955, pp. 73–76 14 refs. Discussion of counting systems, data storage, component structures, design factors, and applications.

Linear Algebraic Computation by Multi-Winding Transformers. Frederick L. Ryder. *J. Franklin Inst.*, May, 1955, pp. 427–439. Design of simplified computing circuits without amplifiers, vacuum tubes, or other components of limited life and without requiring iteration procedures.

Les Machines Mathématiques Électroniques et Leur Utilisation dans l'Industrie Aéronautique. G. R. Serane. *Tech. et Sci. Aéronautiques*, No. 6, 1954, pp. 289–413. In French. Design and operational characteristics of electronic digital and analog computers for aeronautical applications, with diagrammatic details of fundamental circuits.

Multiple Coincidence Magnetic Storage Systems. Robert C. Minnick and Robert L. Ashenhurst. *J. Appl. Phys.*, May, 1955, pp. 575–579. Analysis includes an illustrative storage matrix with toroidal cores etched from a continuous sheet of magnetic material.

An Outline of an Electronic Arithmetic Unit. W. Woods-Hill. *Electronic Eng.*, May, 1955, pp. 212–217. Design and operation of an automatic digital system incorporating a method of checking calculations.

A Reversible Binary Counter. R. W. Fenemore. *Electronic Eng.*, May, 1955, pp. 204–206. Design control and input circuits for add-subtract stages and switching as used in digital analog converters and digital data interpolation.

Education & Training

The Education and Training of an Aeronautical Engineer. Bernard Etkin. *CAI 1st Annual Meeting, Toronto, May 19, 20, 1955, Preprint.* 23 pp.

An Industry Appraisal of the Education and Training of Technical Personnel. Everett B. Schaefer. *CAI 1st Annual Meeting, Toronto, May 19, 20, 1955, Preprint.* 11 pp.

The Possibility of the Flight Simulator as a Training Aid to Helicopter Pilots. Norman Hill and Pierre de Guillenchmidt. *J. Helicopter Assn. Gt. Brit.*, Apr., 1955, pp. 133–146; Discussion, pp. 147–157.

Electronics

Electronic Industries 1955 Directory Issue. *Tele-Tech*, June, 1955. 426 pp. 23

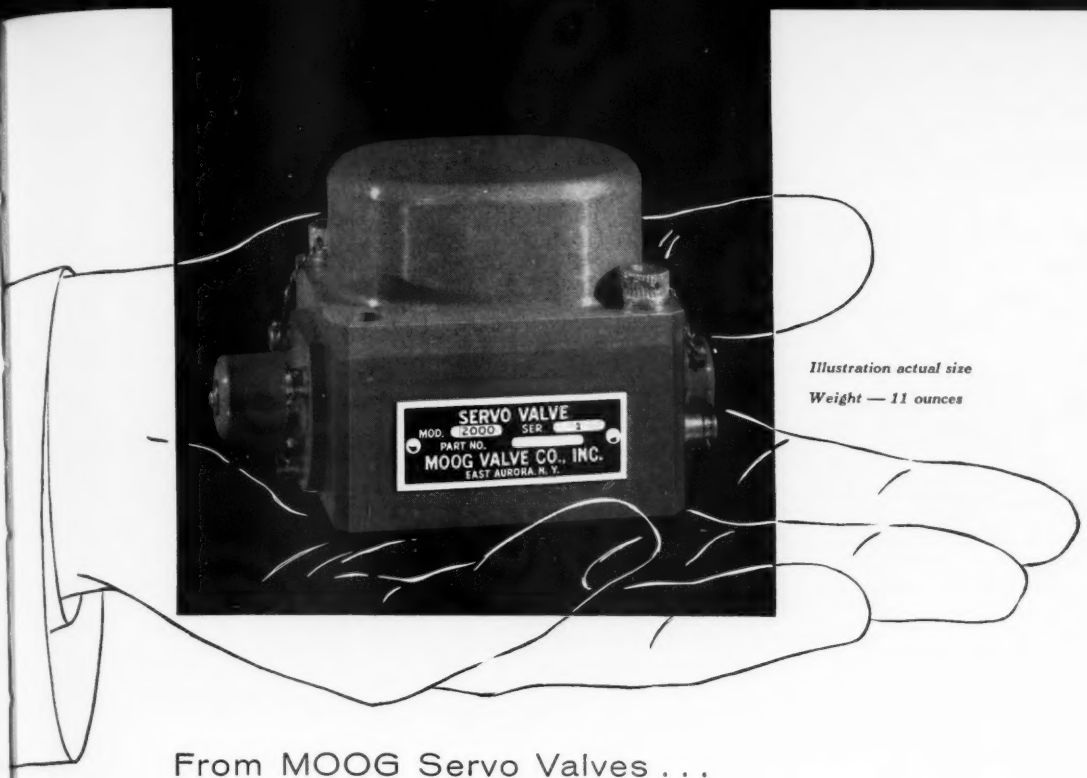


Illustration actual size

Weight — 11 ounces

From MOOG Servo Valves . . .

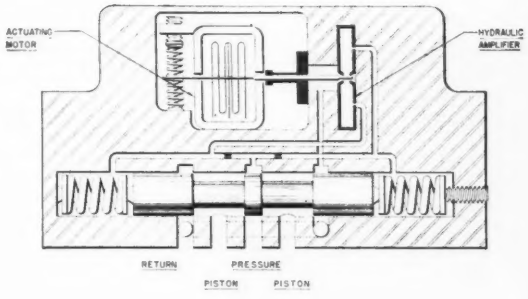
High Accuracy and Response

One of the outstanding characteristics of Moog Servo Valves is their exceptionally high dynamic performance. Moog units are characterized by equivalent time constants as low as one and one half milliseconds from input differential current to output flow.

Performance of this magnitude makes possible control systems of high accuracy and response. Typical applications for these valves are in servo systems of advanced aircraft and guided missile flight controls, radar scanner actuation, contour following machine tools, and automatic packaging equipment.

Conventionally, valve input is from a balanced push-pull DC amplifier and valve flow output is applied to a piston or hydraulic motor. An electric signal proportional to piston position or motor angular rotation is fed back to the amplifier to give a closed servo loop.

Production models are designed to operate in hydraulic systems of from 1000 to 3000 PSI pressure. Rated output flow from 0.1 to 50.0 GPM, for control currents between 2.0 and 40.0 milliamperes as specified, are available in production units.



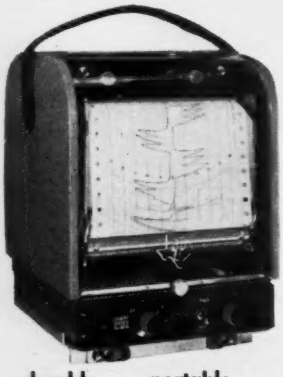
For details write for Bulletin 2000-1

MOOG VALVE CO., INC. PRONER AIRPORT EAST AURORA, N. Y.

Sure it's still writing!

unique clutch actuated dual recording milliammeter

. . . keeps writing accurately — regardless of jolts, tilts or vibration! Designed and built by Texas Instruments, this ink-writing instrument features TI-developed high-torque magnetic fluid clutch meter movements and exclusive enclosed ink system that make it ideal for use in moving vehicles . . . aircraft, jeep, truck or boat. Thousands of these portable recorders in operation throughout the world provide field proof of their writing superiority and trouble-free operation.



durable . . . portable . . . dependable

lightweight — only 15½ lb.

sensitive — one milliampere for full scale (4½ inch) deflection.

fast response — 60 milliseconds full scale rise time; will respond to 10 cps.

eliminates galvanometer — unique TI-developed instrument-sized magnetic fluid clutches replace delicate galvanometer.

dual channel — two independent writing systems and four selective chart speeds within one recorder.

write today for bulletin DL-C 400

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVE. DALLAS 9, TEXAS

refs. Partial contents: Dynamic Testing of Airborne Electronic Components, R. H. Jacobson and M. B. Levine. Figure of Merit in Magnetic Amplifiers, J. T. Carleton and W. F. Horton. Printed Foil Electronic Components, Hubert L. Short and Paul Eisler. Transistor Operating Points, Robert E. Skipper. Designing an Aircraft Magnetic Loop Antenna, Al Hemphill. Simplified R-C Network Analyzer, Perry A. Seay. Systems Engineering for Flight Instruments, Part II, Lawrence J. Fogel. Survey of Power Transistors Currently Available, R. P. Turner. Graphical Construction of Reflected Wavefronts, David K. Cheng and Pranas Grusauskas.

Amplifiers

The Band-Pass Distributed Amplifier. V. C. Rideout and T. P. Tung. *J. Indian Inst. Sci., Sect. B*, Apr., 1955, pp. 138–161. 10 refs. General expressions for the gain of a simple distributed amplifier with any number of tubes joined by identical reactive symmetrical filter sections, with or without unsymmetrical terminating sections at the ends of the filter chains.

Feedback-Stabilized Transistor Amplifier. Dean W. Slaughter. *Electronics*, May, 1955, pp. 174, 175. Army-sponsored development at the CIT Jet Propulsion Lab.; basic design and operational principles, with circuit details.

Antennas

Aircraft Antennas. J. V. N. Granger and J. T. Bolljahn. *Proc. IRE*, May, 1955, pp. 533–550. 19 refs. Analysis of the electromagnetic behavior of an airframe and the operational, electrical, and mechanical requirements in terms of design, communications, and navigational problems and criteria.

Antenna System for Missile Telemetering. Garth E. Bower and James B. Wynn, Jr. *Electronics*, June, 1955, pp. 164–167. Design, development, and operational characteristics of the system incorporating dual helical antennas and a low-noise preamplifier and associated multicoupler for receiving signals telemetered from guided missiles in the 216–235 mc. range.

Design of Line-Source Antennas for Narrow Beamwidth and Low Side Lobes. T. T. Taylor. (*Hughes Aircraft Co. Tech. Memo. 316*, 1954.) *Trans. IRE (AP Ser.)*, Jan., 1955, pp. 16–28. 22 refs. USAF-sponsored development.

Discussion on Optimum Patterns for Endfire Arrays. R. L. Pritchard. *Trans. IRE (AP Ser.)*, Jan. 1955, pp. 40–43. Development of a synthesis procedure based on the Dolph method for the broadside array.

Double Parabolic Cylinder Pencil-Beam Antenna. R. C. Spencer, F. S. Holt, H. M. Johanson, and J. Sampson. *Trans. IRE (AP Ser.)*, Jan., 1955, pp. 4–8.

Fan-Pencil Antenna for Search Radar. Vernon E. Trinter. *Electronics*, May, 1955, pp. 142, 143. Design consisting of flared H-plane horn with movable side walls used in conjunction with a single reflector for closer inspection of target objects.

On the Input Conductance of Thin Antennas. Giorgio Barzilai. *Trans. IRE (AP Ser.)*, Jan., 1955, pp. 29–32. Computation of the conductance by evaluating separately input voltage and radiated power for a prescribed value of the current near the maximum.

Operating Characteristics of the Four-Loop VOR Antenna in the 108-Mc to 112-Mc Band. William L. Wright. *U.S., CAA TDR 257*, Mar., 1955. 6 pp.

Optimum Design of Directive Antenna Arrays Subject to Random Variations. E. N. Gilbert and S. P. Morgan. *Bell System Tech. J.*, May, 1955, pp. 637–663.

A Single-Control Tuning Circuit for Electrically Small Antennas. R. E. Webster. *Trans. IRE (AP Ser.)*, Jan., 1955, pp. 12–15. Application to airborne tunable cavity antenna.

Capacitors

Capacitor Miniaturization with Plastic Films. George Mistic. *Aero Dig.*, May, 1955, pp. 54, 56, 58, 60. Design and other factors to meet airborne operational problems, with a comparison of the characteristics of synthetic and natural dielectrics.

Circuits & Components

Cooling—Another Problem for the Electronics Engineer. B. I. McCaffrey. *Aircraft* (Canada), May, 1955, pp. 21, 22, 24, 69. Analytical evaluation of design and other requirements to maintain optimum temperature levels for airborne components.

A Maintenance Plan for Airborne Radio Equipment. T. R. W. Bushby. *Trans. IRE (ANE Ser.)*, Sept., 1954, pp. 2–7. Development of a probability criterion of unscheduled removals of components to assess the optimum period between scheduled overhauls.

A Design Method for Direct-Coupled Flip-Flops. W. Renwick and M. Phister. *Electronic Eng.*, June, 1955, pp. 246–250. Operational characteristics of a bistable trigger circuit; applications include high speed automatic digital computers.

Directly Coupled Transistor Circuits. Ralph H. Beter, William E. Bradley, Ralph B. Brown, and Morris Rubinoff. *Electronics*, June, 1955, pp. 132–136. Design and operational characteristics; applications include computers and control elements.

Junction-Transistor Trigger Circuits. J. E. Flood. *Wireless Engr.*, May, 1955, pp. 122–130. 17 refs. Experimental investigation of simple pulse circuit applications, including bistable, monostable, and emitter-coupled trigger and scale-of-two circuits and a blocking oscillator design.

A Time-Delay Device Using Transistors. G. F. Pittman, Jr. *Elec. Eng.*, June, 1955, pp. 498–501. For pulse-shaping and pulse-counting functions, with basic circuitry and principles of operation for reliable performance.

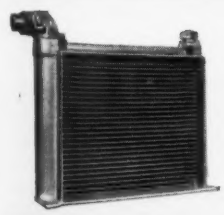
Communications

Helicopter Communications on 2½ Meters. Richard A. Girvin. *Radio & TV News*, June, 1955, pp. 64, 65. A two-way coordinated operational system at the Los Angeles Airport.

Harrison watches the copters' calories!

The sky's the limit for the "whirlibirds"! Every day they're flying faster . . . farther . . . with bigger payloads! And Harrison oil coolers are on the job—holding the heat line—keeping transmission and engine temperatures at the *right* levels for peak operating efficiency. What's more, Harrison oil coolers are designed to save space and weight. With its unexcelled research facilities, Harrison is always looking for new ways to make aircraft heat exchangers lighter, more dependable, more durable! If you have a cooling problem, look to Harrison for the answer!

HARRISON RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N.Y.



TEMPERATURES MADE TO ORDER

HARRISON

Construction Techniques

Band-Pass Filters Using Strip-Line Techniques. E. H. Bradley and D. R. J. White. *Electronics*, May, 1955, pp. 152–155. Use of etched wiring and sandwich construction in the fabricational design to obtain space and weight savings at high performance in coaxial lines.

Printed Circuits Have Versatility Plus. Hubert L. Shortt. *Elec. Mfg.*, June, 1955, pp. 108–115. Relative merits of the fabricational technique; applications include contact decks in compact switches, resistance strain gages, power transformers, airplane deicers, and wiring harnesses.

Dielectrics

Arc Resistance of Plastics. C. F. Spiers and W. C. Wikstrand. *Prod. Eng.*, May, 1955, pp. 174–180. Test data on 13 insulating materials to determine arc resistance and tracking characteristics; applications.

Diffusion, Static Charges, and the Conduction of Electricity in Nonmetallic Solids by a Single Charge Carrier. I—Electric Charges in Plastics and Insulating Materials. II—Solution of the Rectifier Equations for Insulating Layers. Selby M. Skinner. *J. Appl. Phys.*, May, 1955, pp. 498–508; 509–518. 38 refs. USAF WADC Aero. Res. Lab.-supported investigation.

Impact of High-Energy Radiation on Dielectrics. Alex. E. Javitz. *Elec. Mfg.*, June, 1955, pp. 85–104. 20 refs. Analysis of design principles, operational and environmental conditions, properties, and applications of insulating materials.

Electronic Controls

Feedback Relations in Military Weapon Systems. R. C. Newhouse. *Trans. IRE (ANE Ser.)*, Sept., 1954, pp. 24–27. Application of automatic control principles to such military problems as communications, directional computations, and missile guidance.

Frequency Response from Transient-Response Data. A. Thal-Larsen. *Elec. Eng.*, June, 1955, p. 518. Abridged. Application to feedback control systems.

Electronic Tubes

The Cold-Cathode Gas Diode; Special Circuits and Improved Voltage Characteristics May Make This Component Useful in Computers. *U.S., NBS Tech. News Bul.*, May, 1955, pp. 61–66.

The Distribution of Temperature Along a Thin Rod Electrically Heated in Vacuo. VI—End-Losses. S. C. Jain and K. S. Krishnan. *Proc. Royal Soc. (London), Ser. A*, May 24, 1955, pp. 439–445. NPL (India) experimental investigation; application to the design of electronic tubes.

An Electromagnetic Difference-Equation of Importance in the Theory of Traveling-Wave Tubes. Heinrich Derfler. *ZAMP*, Mar. 25, 1955, pp. 104–114.

Thermionic Valves of Improved Quality for Government and Industrial Purposes. E. G. Rowe, P. Welch, and W. W. Wright (*IEE Paper 1740 R.*) *Proc. IEE, Part B*, May, 1955, pp. 343–357; Discussion, pp. 357–363. 102 refs. Detailed study of the principal facets of reliability requirements of tubes under vibration and shock conditions, with a comprehensive bibliography; operational and structural characteristics; testing criteria, procedures, and equipment; applications, trends, and potentialities.

Magnetic Devices

Alloy Improves Magnetic Recording. Carroll W. Lufcy and Wesley T. Heath. *Electronics*, June, 1955, pp. 137–139. Evaluation of high-aluminum-content iron alloy Alfenal for recording heads to gain the advantages of wear resistance, increase in resolution, and decreasing in core losses; applications include FM/FM telemetering systems and devices for vibration analysis of projectiles.

Newer Types of Magnetic Amplifiers. R. R. Jackson. *Eng. J.*, May, 1955, pp. 635–639. 13 refs. Developmental review of fundamental design and operational principles, characteristics, and applications.

Pulse-Switching Circuits Using Magnetic Cores. M. Karnaugh. *Proc. IRE*, May, 1955, pp. 570–584. 31 refs. Analysis of basic principles, design methods, operational characteristics, and potentialities of the switching circuits for nonstorage functions of digital computers; includes a bibliography on materials, pulse response, shift registers, logic and memory circuits, and the physics of flux reversal.

Measurements & Testing

Automatic Control and Display in Impulse Testing. R. F. Saxe. (*IEE Paper 1839 M.*) *Proc. IEE, Part B*, May, 1955, pp. 371–374.

Measurement of High Permittivity Dielectrics at Microwave Frequencies. Frank E. Harris and Chester T. O'Konski. *Rev. Sci. Instr.*, May, 1955, pp. 482–485.

Testing for Instrument Fragility. J. T. Muller. *SAE Golden Anniv. Aeronautic Meeting, New York, Jan. 18–21, 1955, Preprint 491.* 6 pp. Sperry procedure to determine vibration and shock response characteristics of a Klystron SRX-20.

A Transient Pulse Width and Pulse Amplitude Meter. F. Hart. *Electronic Eng.*, May, 1955, pp. 192–197. Basic design and operational principles, with circuit details; applications.

Navigation Aids

Airborne Interrogator Spots Location. A. R. Applegarth. *Electronics*, May, 1955, pp. 170–173. Design and operational characteristics of the DME system, with circuit details.

Networks

Design of Parallel-T Resistance-Capacitance Networks. Yosiro Oono. *Proc. IRE*, May, 1955, pp. 617–619.

Nyquist's and Thevenin's Theorems Generalized for Nonreciprocal Linear Networks. R. Q. Twiss. *J. Appl. Phys.*, May, 1955, pp. 599–602. Derivation of the necessary conditions for the realizability of passive nonreciprocal networks; application of results to a system of coupled antennas in an equi-thermal enclosure.

On the Physical Realizability of Linear Non-Reciprocal Networks. H. J. Carlin. *Proc. IRE*, May, 1955, pp. 608–616. 19 refs. USAF-sponsored study.

A Simplified Method for the Design of Logical Conversion Matrices. M. L. Klein. *Electronic Eng.*, June, 1955, pp. 270–272. Potential practical applications for programming sequence control systems.

Noise & Interference

Cross Correlation between Velocity and Current Fluctuations in Tube Noise. S. V. Yadavalli. *J. Appl. Phys.*, May, 1955, pp. 605–608. 12 refs. USAF WADC-supported study.

Mean Frequency Determination of Narrow-Band Noise Spectra. W. W. H. Clarke and R. F. Nikkel. (*IEE Paper 1836 M.*) *Proc. IEE, Part B*, May, 1955, pp. 364–370. Theoretical and experimental investigation of basic problems.

Noise at the Potential Minimum in the High-Frequency Diode. D. A. Watkins. *J. Appl. Phys.*, May, 1955, pp. 622–624. 13 refs. USAF-Army-Navy-supported research.

Noise in One-Dimensional Electron Beams. Hermann A. Haus. *J. Appl. Phys.*, May, 1955, pp. 560–571. USAF-ONR-Army-supported investigation of the problem at MIT.

Techniques for Noise Measurement and Evaluation of Data. R. S. Gales. *Noise Control*, May, 1955, pp. 22–29. 10 refs. Means of presenting and interpreting data on problems.

Oscillators & Signal Generators

Optimum Characteristics of Linear Pulse Systems. R. Kulikowski and J. Plebański. *Bul. Acad. Polonaise Sci.* (Warsaw), No. 1, 1955, pp. 23–28.

Parallel-Network Oscillators. J. L. Stewart. *Proc. IRE*, May, 1955, pp. 589–595. Analyses of principal designs, operational characteristics, and potentialities.

Unit R-C Oscillator—20 Cycles to 500 Kc. A. G. Bousquet, A. P. G. Peterson and D. B. Sinclair. *Gen. Radio Exp.*, May, 1955, pp. 1–11. 13 refs. Design and operational characteristics; applications include sweep and recording circuits.

Waveform Generator Uses Pulse Techniques. E. E. Newhall. *Electronics*, June, 1955, pp. 149–151. Design of a drift-free flying-spot scanner type of function generator for use with analog computers.

Radar

Local Oscillator for C-W Radars. Harold B. Goldberg. *Electronics*, May, 1955, pp. 166, 167. Design of a system eliminating the klystron in X-band circuits, with experimental results.

The Operational Applications of Airborne Radar. E. A. Post. *Trans. IRE (ANE Ser.)*, Sept., 1954, pp. 15–23. Outline of the experimental 5.5-cm. radar installation used for the United Airlines evaluation, its flight test results, and recommendations.

A Thunderstorm Avoidance Radar for Civil Aircraft. C. L. Greenslit. *Trans. IRE (ANE Ser.)*, Sept., 1954, pp. 7–14. Design and operational parameters for the Bendix Airborne Radar RDR-1 System as a solution for certain basic flight problems.

Resistors

Wirewound Resistors; Some Practical Considerations in Design of the Types

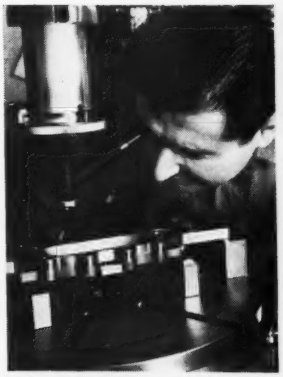
9 reasons why the aviation industry depends on Johns-Manville Goetze Gaskets

Highly skilled and experienced tool and diemakers provide the precision workmanship that assures superior gasket performance

J-M Goetze metal gaskets consistently maintain a tight seal despite the new and more rigorous conditions found in modern aircraft. Starting with the superb craftsmanship of J-M tool and diemakers, Johns-Manville follows through each step of production with the most modern methods of manufacturing and quality control.

As a result, the 40 million gaskets produced by J-M each year are masterpieces of precision and accuracy. This means not only better performance in flight, but is frequently an important factor in the safety and comfort of the crew.

Let Johns-Manville gasket experts tackle your sealing problems. J-M technicians will work directly with your own engineers to develop new gaskets—or adapt existing styles—to meet your specific needs, no matter how intricate. Write today for further information on Johns-Manville Goetze Gaskets and other products for aviation. Ask for Brochure AV-1A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, Port Credit, Ontario.



Microscopic accuracy of J-M Goetze Gaskets is provided by expert J-M technicians working with modern equipment.

THERE'S A J-M GASKET FOR EVERY SEALING PROBLEM

Spirotallic | Corrugated Metal | Screen | French Type | Single Bead | Mesh Filled | Non-Metallic

JOHNS-MANVILLE JM PRODUCTS **Johns-Manville** PRODUCTS FOR THE AVIATION INDUSTRY

Used in the Electronic Industry. R. H. Mapplebeck. *Electronic Eng.*, June, 1955, pp. 254–257.

Semiconductors

Recovery Time Measurements on Point-Contact Germanium Diodes. T. E. Firle, M. E. McMahon, and J. F. Roach. *Proc. IRE*, May, 1955, pp. 603–607.

Silicon Power Rectifiers. William E. Slusher. *Elec. Mfg.*, June, 1955, pp. 120–123, 332. Evaluative study of the design, operational characteristics, and advantages of the rectifiers for military applications.

Some Aspects of the Design of Power Transistors. N. H. Fletcher. *Proc. IRE*, May, 1955, pp. 551–559.

The Theory and Construction of Germanium Diodes. J. C. van Vessem. (*Phillips Tech. Rev.*, Feb., 1955, pp. 213–224.) *Engr. Dig.*, May, 1955, pp. 196–201. Includes an analysis of conductivity compared with silicon, effects of impurities, rectification and formation of *p-n* junctions, and behavior at high frequencies and temperatures.

Telemetry

Data Reduction System for Missile Telemetering. E. M. McCormick. *Electronics*, May, 1955, pp. 126–130. NOL-developed FM/FM design capable of handling pulse-width signals and analog-to-digital conversions.

Transmission Lines

Coupled Transmission Lines as Symmetrical Directional Couplers. G. D. Monteath. (*IEE Paper 1833 R.*) *Proc. IEE, Part B*, May, 1955, pp. 383–392.

An Experimental Investigation of Axial Cylindrical Surface Waves Supported by Capacitive Surfaces. H. E. M. Barlow and A. E. Karbowiak. (*IEE paper 1786 R.*) *Proc. IEE, Part B*, May, 1955, pp. 313–322. 15 refs.

Interaction of Moving Charges with Wave Circuits. I—A Moving Charge Interacting with a Nondispersive Transmission Line. II—Unaccelerated Motion with a Dispersive Circiut. J. R. Pierce. *J. Appl. Phys.*, May, 1955, pp. 627–638.

The Matrix Approach to Filters and Transmission Lines. I, II. M. E. Fisher. *Electronic Eng.*, May, June, 1955, pp. 198–204; 258–263. 11 refs. Development of a simple graphical method for finding the nature of the pass bands of any filter, the attenuation and speed of the waves on a filter, and their variation with frequency.

On Transients in Wave Guides. R. Gajewski. *Bul. Acad. Polonaise Sci.* (Warsaw), No. 1, 1955, pp. 29–34.

Wave Propagation

The Scattering of a Scalar Wave by a Semi-Infinite Rod of Circular Cross Section. D. S. Jones. *Philos. Trans. Royal Soc.* (*London*), *Ser. A*, Apr. 19, 1955, pp. 499–528. 16 refs. Applications include antenna design problems.

Theory of Radio Reflections from Electron-Ion Clouds. R. Eshleman. *Trans. IRE* (*AP Ser.*), Jan., 1955, pp. 32–39. 12 refs. USAF-ONR-Army-supported investigation at the Stanford U. Radio Propagation Lab.

Equipment

Electric

The Design and Execution of Electrical Installations; Recommendations for the Arrangement and Installation of Aircraft Electrical Equipment. F. B. Brookesmith. *Aircraft Eng.*, May, 1955, pp. 140–144.

Hydraulic & Pneumatic

Aeration in Lubrication and Hydraulic Systems. B. R. Walsh. *Prod. Eng.*, May, 1955, pp. 136–139. Design of an ideal system incorporating optimum techniques and devices to minimize the problem.

Directional Valves for Hydraulic Circuits. Warren Brown. *Prod. Eng.*, June, 1955, pp. 186–192. Design principles for standard check, pilot-operated check, deceleration four-way spring centered, and solenoid-actuated valves; applications.

How to Reduce Weight of Aircraft Hydraulic Systems. I—By Circuit Design. K. G. Hancock. *Appl. Hydraulics*, June, 1955, pp. 74, 76, 78, 80, 81. Analysis includes maximum power requirements, location of services, method of driving pumps, operating pressures and temperatures, and controls.

Liquid Springs: Progress in Design and Application. A. E. Bingham. *Chartered Mech. Engr.*, May, 1955, pp. 249–252. Abridged. Analysis of basic factors including valve cylinder stresses, auto-frettage, compressibility, pressurization, and temperature compensation as in aircraft shock absorbers.

Practical Pressure—3000 psi for Aircraft Hydraulic Systems. Conrad H. Cooke. *Appl. Hydraulics*, May, 1955, pp. 86 ff. (4). Results of WADC and NavBuAer investigations to determine optimum pressures, taking into account the factors of weight, space, reliability, servo design, temperature control, and costs.

Flight Operating Problems

Cruise Control and Piloting

Einige Probleme der Luftfahrzeugführung. Heinrich Koppe. *ZFW*, Mar.–Apr., 1955, pp. 80–87. 14 refs. In German. Piloting problems arising out of high-speed, long-distance, and high-altitude flights.

Fuels & Lubricants

Chaleurs Spécifiques et Entropies des Hydrocarbures et de Quelques Combustibles Liquides. M. Aubert and N. Sivolobov. *France, Min. de l'Air PST 297*, 1955. 202 pp. 20 refs. In French. Analytical study of the specific heat ratings and entropies of a number of hydrocarbons and combustible liquids.

A Critical Survey of Commercial Turbine Fuels. H. E. Alquist and R. M. Schirmer. *SAE Golden Anniv. Aeronautic Meeting, New York, Apr. 18–21, 1955, Preprint 520.* 20 pp. 21 refs.

Liquid Oxygen as a Rocket Propellant. S. Allen. *J. Brit. Interplanetary Soc.*, May–June, 1955, pp. 165–168. Appraisal of relative merits in terms of rocket design and performance, production capabilities, storage, and handling.

Using Hydrogen Peroxide. A. V. Cleaver. *J. Brit. Interplanetary Soc.*, May–June, 1955, pp. 159–164. Evaluation of the properties, operational advantages in terms of safety and reliability factors related to rocket problems, and methods of manufacture and handling.

Comparaison de la Résistance au Choc des Films Lubrifiants. F. Charron. *France, Min. de l'Air PST 298*, 1955. 18 pp. In French. Experimental investigation of the protective properties of film lubricants under operational and shock conditions relative to viscosity at atmospheric and high pressures.

Friction, Wear, and Surface Damage of Metals as Affected by Solid Surface Films. Appendix A—Adhesion Theory of Friction. Appendix B—Film Preparation. Edmond E. Bisson, Robert L. Johnson, Max A. Swikert, and Douglas Godfrey. *U.S., NACA TN 3444*, May, 1955. 60 pp. 48 refs.

Gliders

Esperienze alla Galleria del Vento su un Nuovo Tipo di Freni Aerodinamici per Alianti (Wind Tunnel Tests on a New-Type of Aerodynamical Brakes for Gliders). Piero Morelli. *L'Aerotecnica*, Feb., 1955, pp. 17–21. In Italian.

The Powered Sailplane. I. Harry N. Perl. *Soaring*, May–June, 1955, pp. 2, 3, 6, 7. Design problems of the self-launching Nelson Hummingbird.

Soviet Flapping Wing Sailplane Provides Design Data. R. Sheremetev. *Aero Dig.*, May, 1955, pp. 30, 31. Experimental characteristics of the Kashuk; potential application to flight investigations of wing flutter, load and stress factors, and wind gusts.

Instruments

Measurement Errors—Classification and Interpretation. J. C. Boonshaft. *Trans. ASME*, May, 1955, pp. 409–411. Recognition of precision factors of numerical value in indicating and recording instruments.

Automatic Control

Application Factors for Two-Phase Servo Motors. Sidney A. Davis and Julian Spector. *Elec. Mfg.*, June, 1955, pp. 76–84. Design and operational principles.

A Harmonic Response Plotter. Z. Czajkowski. *Electronic Eng.*, May, 1955, pp. 207–211. Design of an automatic electro-mechanical analog system incorporating six servomechanisms to give rapid and accurate indication of the frequency response of servo devices.

Flight Instruments

Mach Number and True Air Speed Measurement. J. F. Manildi. *ISA J.*, Apr., 1955, pp. 114–116. Analysis of fundamental principles and limitations of instrumentation to solve problems of clear indication.

An NACA Vane-Type Angle-of-Attack Indicator for Use at Subsonic and Super-

Martin "404"—COURTESY OF THE GLENN L. MARTIN COMPANY

Ever try flying without vibration control?

It just can't be done! At least not with the comfort and safety that are taken for granted in modern aviation. LORD VIBRATION CONTROL systems play an important part in every type of aircraft—isolating the vibration of powerful engines, protecting the accuracy of vital and delicate instruments, and insuring the comfort of operators and passengers.

With the same effectiveness, LORD VIBRATION CONTROL enhances the performance of all types of mechanical equipment—providing quieter, more efficient operation.

The distinct advantages of LORD VIBRATION CONTROL systems are the result of three important factors. First is LORD's extensive knowledge of vibration causes, effects and control gained through 30-plus years of experience devoted exclusively to this field.

Second is the completeness of LORD facilities for every phase of vibration research, control engineering, and precision volume production of uniform, high quality products.

Third is the use of quality materials in all LORD products — each selected and proved for maximum performance.

LORD VIBRATION CONTROL ENGINEERS, at the Home Office and in the field, will gladly show you the "plus" features LORD bonded rubber products will add to your particular equipment.

LORD MANUFACTURING COMPANY • ERIE, PENNSYLVANIA

LOS ANGELES, CAL. HOllywood 4-7593
PHILADELPHIA, PENNA. LOcust 4-0147
DALLAS, TEXAS Riverside 3392
DAYTON, OHIO MIchigan 8871
DETROIT, MICH. TRinity 4-2060
CHICAGO, ILL. MIchigan 2-6010
NEW YORK, N. Y. Circle 7-3326
CLEVELAND, OHIO SUperior 1-3242

LORD BONDED RUBBER

DESIGNERS AND PRODUCERS OF BONDED RUBBER PRODUCTS SINCE 1924

TO THE FINE ENGINEERING MIND
SEEKING THE CHALLENGING PROJECTS IN

AIR CONDITIONING

AIR CONDITIONING DESIGN AND DEVELOPMENT ENGINEERS are offered special career opportunities now at Convair in cool, beautiful San Diego, California. Experience should be in the areas of air turbine motor installation, gas turbine compressor installations, and general air condition systems for military and commercial airplanes including cabin superchargers, refrigeration packages, heat exchangers, water separators and high and low pressure ducting.

CONVAIR offers you an imaginative, explorative, energetic engineering department to challenge your mind, your skills, and your abilities in solving the complex problems of vital, new, immediate and long-range programs. You will find salaries, facilities, engineering policies, educational opportunities and personal advantages excellent.

SMOG-FREE SAN DIEGO, lovely, cool city on the coast of Southern California, offers you and your family a wonderful new way of life... a way of life judged by most as the Nation's finest for climate, natural beauty, and easy (indoor-outdoor) living.

Generous travel allowances to engineers who are accepted. Write at once enclosing full resume to:

H. T. Brooks, Engineering Personnel, Dept. 508

CONVAIR

A Division of General Dynamics Corporation

3302 PACIFIC HIGHWAY **SAN DIEGO, CALIFORNIA**

sonic Speeds. Jesse L. Mitchell and Robert F. Peck. (*U.S., NACA RM L9F28a*, 1949.) *U.S., NACA TN 3441*, May, 1955. 8 pp.

A New Differential Rate-of-Climb Meter. Shin'ichiro Takeda. *J. Japan Soc. Aero. Eng.*, Feb.–Mar., 1955, pp. 1–7. In Japanese. Theoretical and experimental design to indicate the vertical acceleration of an aircraft by the change of atmospheric pressure.

Systems Engineering for Flight Instruments. II. Lawrence J. Fogel. *Tele-Tech*, June, 1955, pp. 111 ff. (2).

Flow Measuring Devices

Cantilevered Pitot Cylinder. F. A. L. Winternitz. *The Engr.*, May 27, 1955, pp. 729–732. 24 refs. Experimental investigation of the properties under "free stream" conditions in a towing tank and in correlated wind-tunnel tests; study of the effects of probe tip shape, orifice distance from tip, flutter, Reynolds Number, and inclined flow.

Heat-Loss Characteristics of Hot-Wire Anemometers at Various Densities in Transonic and Supersonic Flow. W. G. Spangenberg. *U.S., NACA TN 3381*, May, 1955. 82 pp.

The Measurement of Flow with Density Compensation as Applied to Liquids and Gases. Henry W. Stoll. *ISA J.*, May, 1955, pp. 159–162. Functional requirements of measuring devices for time indication of mass transfer rates, with typical designs.

A Quick Response Variable Flow Control Device. V. L. Streeter. *ISA J.*, Feb., 1955, pp. 48–51. Theory and design of controller using a disc moving axially within a profiled throat section resisted by a nonlinear spring on an adjustable support to permit infinitely variable adjustment.

Pressure Measuring Devices

The Present Status of High Pressure Measurement and Control. I, II. Wilfred H. Howe. *ISA J.*, Mar., Apr., 1955, pp. 77–79; 109–112.

Temperature Measuring Devices

The Dynamics of Filled Temperature-Measuring Systems. Otto Muller-Girard. *Trans. ASME*, May, 1955, pp. 591–595.

Machine Elements

Bearings

Bearing Loads on Geared Shafts. Zbigniew Jania. *Prod. Eng.*, June, 1955, pp. 209, 211, 213. Simple, rapid, and accurate graphical method of calculating direction and magnitude of loads.

Berechnung einer Kurbelwellenpressverbindung für Sternmotoren. Kurt Löhner and Günter Stahl. *ZFW*, Mar.-Apr., 1955, pp. 94–99. In German. Analytical procedures to fit unsplit connecting rod bearings on the crankpin of crank shafts of radial and other types of engines.

Calcul de l'Aplatissement d'un Cylindre Comprimé Entre Deux Autres Cylindres Suivant Deux Génératrices Diamétralement Opposées. Jean Hondet. *Tech. et Sci. Aéronautiques*, No. 1, 1955, pp. 12–22. In French. Determination of the elastic

PRECISE
ABSOLUTE
PRESSURE

From 100 Microns Up

TYPE FA-160

...Ranges: 0.1–20 mm thru 800 mm Hg absolute in six ranges.
...Accuracy: 1 part in 300 over full scale.
...Sensitivity: 1 part in 500 in *all* ranges.
...Available with 2¾" or 6" dia. dial.

Write for Publication No. TP-28-A A-105

WALLACE & TIERNAN
INCORPORATED
PRECISION INSTRUMENTS AND ELECTRICAL MECHANISMS
25 MAIN ST. BELLEVILLE 9, N. J.
In Canada: Wallace & Tiernan, Ltd., Toronto

A COMPLETE MEDIA PACKAGE
FOR YOUR
Aviation Marketing Program

AERONAUTICAL ENGINEERING REVIEW

For your monthly advertising message to the aircraft industry's engineering and design personnel—the men who influence buying.

1955
MEDIA
DATA
FILE
Available!

12 pages of FACTS on your market and REVIEW.

Write for free copy TODAY!

AERONAUTICAL ENGINEERING CATALOG

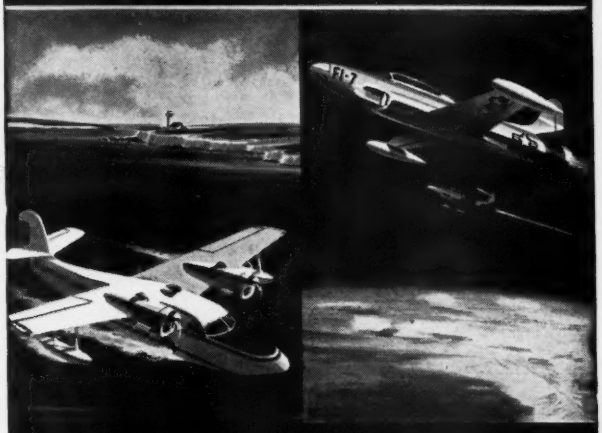
Prefiles and distributes your aircraft products catalog to aviation's buyers and specifiers.

7,000 copies are distributed annually to aircraft engineers, designers, technicians and purchasing agents in all leading aircraft, engine and parts companies, Government aviation departments and leading air lines.

Write for your free copy of 8-page Booklet giving full details.

OFFICIAL PUBLICATIONS
INSTITUTE OF THE AERONAUTICAL SCIENCES
2 East 64th Street New York 21, N.Y.

From Water Level To Stratosphere...



Pittsburgh FABSEAL

Makes Flying Safer... More Efficient!

Millions of flying hours prove the dependable performance of these impregnated fabric tapes in civilian and military use!

● Many of America's leading builders of aircraft use Pittsburgh's FABSEAL Tapes with complete confidence in their outstanding quality to seal flying boats, pressurized cabins and for other applications where there is considerable racking movement.

● FABSEAL Tapes are impregnated fabric of uniform density, resistant to water, gasoline and oil. They are available in .015" thickness and in widths from ½" to 12", packages in rolls of 50 feet.

● These tapes are particularly designed for use in fluid or air containers where excessive pressures are experienced. They are also adapted for sealing structural members where flexibility and vibration present unusual requirements. FABSEAL Tapes can also be bolted, riveted or screwed between metal, wood or fiber members to provide a fillet that assures a complete seal.

● Call on us for advisory service. Our wide experience in the aircraft field often can save you time and money.

PITTSBURGH PLATE GLASS CO., Industrial Paint Div., Pittsburgh, Pa. Factories: Milwaukee, Wis.; Newark, N. J.; Springdale, Pa.; Houston, Texas, Los Angeles, Calif.; Portland, Ore. Ditzler Color Div., Detroit, Michigan. The Thresher Paint & Varnish Co., Dayton, Ohio. Forbes Finishes Division, Cleveland, Ohio. M. B. Suydam Div., Pittsburgh, Pa.

PITTSBURGH PAINTS
PAINTS • GLASS • CHEMICALS • BRUSHES • PLASTICS • FIBER GLASS
PITTSBURGH PLATE GLASS COMPANY

compression or flattening of a cylinder between two others cylinders following two generators dimetrically opposed; application to roller bearing and other problems of rolling mechanisms.

Comparison of Performance of Experimental and Conventional Cage Designs and Materials for 75-Millimeter-Bore Cylindrical Roller Bearings at High Speeds. William J. Anderson, E. Fred Macks, and Zolton N. Nemeth. (*U.S., NACA TN 3001, TN 3002,* 1953.) *U.S., NACA Rep. 1177,* 1954. 15 pp. 12 refs. Supt. of Doc., Wash. $0.20.

Quelques Aperçus Inédits sur le Palier Fluide. H. Castanié. *Tech. et Sci. Aéronautiques,* No. 6, 1954, pp. 426–428. In French. Some unpublished notes on the characteristics and development of fluid bearings.

Fastenings

Fatigue Analysis of Aircraft Bolts. Harold G. Brilmyer. *Aero. Eng. Rev.,* July, 1955, pp. 48–54. Endurance strength tests of alloy-steel and aluminum-alloy bolt-nut installations, with and without tensile preload.

Friction

The Mechanism of Rolling Friction. I—The Plastic Range. K. R. Eldredge and D. Tabor. **II—The Elastic Range.** D. Tabor. *Proc. Royal Soc. (London), Ser. A,* Apr. 21, 1955, pp. 181–198; 198–220. 34 refs.

Gears & Cams

Accessory-Drive Gearbox; Production by Rotol of the Viscount Series of Units: Acid-Etch Examination of Gear-Teeth. *Aircraft Prod.,* June, 1955, pp. 218–225.

Plate Cam Design: Pressure Angle Analysis. Martin Kloomok and Robert V. Muffley. *Prod. Eng.,* May, 1955, pp. 153–159. Simplified method using computer-developed charts to determine maximum pressure angles to keep compression stresses within allowable limits.

Mechanisms & Linkages

Kinematic Concepts That Simplify Design. M. F. Spotts. *Prod. Eng.,* May, 1955, pp. 152–154. Basic concepts applied to improve the efficiency of linkages and complex mechanisms.

Rotating Discs & Shafts

Symmetrical Thermal Bending of Circular Disks with Power Function Profile. Jacob Herrmann. *J. Franklin Inst.,* May, 1955, pp. 421–426. Analysis for the case of turbine disks subjected to axial temperature especially when starting.

Springs

Springs in the Aircraft Industry. Charles Harris. *J. SLAE,* May, 1955, pp. 9–11. Study of basic design requirements, performance characteristics, and applications.

Torsion Spring Design. I—Application Requirements. II—Basic Spring Calculation. III—Variations and Limits. S. L. Albright. *Prod. Eng.,* June, 1955, pp. 136–143.

Materials

The Development of New Materials. F. E. Robinson. *Marconi Rev.,* 2nd Quarter, 1955, pp. 60–68. Properties, fabricational techniques, and applications of titanium, aluminum, ferrous, powdered, magnetic, plastic, and other metals, alloys, and nonmetallic materials.

Corrosion & Protective Coatings

Corrosion Fatigue. E. A. Smith. *Aeronautics,* May, 1955, pp. 40–42. 11 refs. Appraisal of fundamental conditions and practical preventive factors in terms of test results.

Metals & Alloys

Analysis of Ear Formation in Deep-Drawn Cups. Arthur J. McEvily, Jr. *U.S., NACA TN 3439,* May, 1955. 7 pp. Method based on the plastic properties of single crystals and a knowledge of the preferred orientation of the blank material to predict earing behavior.

A Design Guide to Production Characteristics of Engineering Metals. *Mach. Des.,* May, 1955, pp. 156–231. Comprehensive analyses by 14 authors of basic properties, applications, and fabricational procedures.

A Dictionary of Metallurgy. XXXIII—*Pl-Pr.* A. D. Merriman and J. S. Bowden. *Metal Treatment,* May, 1955, pp. 203–210.

Metals & Alloys, Nonferrous

The Dependence on Orientation of the Plastic Deformation with Low Elongations of Aluminium Monocrystals. G. Masing and H. Weik. (*Z. für Metallkunde,* Germany, July, 1954, pp. 417–428.) *Gt. Brit., MOS TIB/T4435,* Feb., 1955. 20 pp.

Propagation of Shock Waves in Aluminum. H. Dean Mallory. *J. Appl. Phys.,* May, 1955, pp. 555–559. Use of an electrical contact technique to determine experimentally the velocity of shock waves in aluminum and the associated translational motions produced by metal-to-metal impact.

A Further Examination of the Welding and Tensile Properties of some Al-Zn-Mg Alloys containing Copper. W. I. Pumphrey and D. C. Moore. *Brit. Welding J.,* May, 1955, pp. 206–215.

Les Pièces Moulées en Alliages Magnésium-Zirconium dans la Construction Aéronautique. R. Pradeau. *Tech. et Sci. Aéronautiques,* No. 1, 1955, pp. 23–29. In French. Basic properties, structural, fabricational, and mechanical characteristics of magnesium-zirconium casting alloys for aeronautical applications.

Titanium Alloys for Aircraft. H. V. Kinsey. (*CAI 1st Annual Meeting, Toronto, May 19, 20, 1955, Preprint.*) *Canada, Dept. Mines & Tech. Surveys Rep.,* Apr. 25 1955. 22 pp. 21 refs. Study of basic properties, design, meteorological, and fabricational characteristics.

Nonmetallic Materials

Plastics in Aviation. E. A. Smith. *Aeronautics,* June, 1955, pp. 60, 61. Evaluative summary of the relative merits in particular applications.

Sandwich Materials

The Buckling and Bending of Orthotropic Sandwich Panels With All Edges Simply-Supported. Appendix—Mathematical Theory. J. R. Robinson. *Aero. Quart.,* May, 1955, pp. 125–148.

Testing

The Effect of Grinding on the Fatigue Strength of Steels. D. N. Cledwyn-Davies. *IME Proc.,* No. 2, 1955, pp. 83–91; Communications, pp. 91, 92. Tests on nickel-chromium-molybdenum alloy steels hardened and tempered to give a nominal ultimate stress of 80 tons and 62 tons per sq. in. (Vibrac V30) and on 0.6 and 0.1 per cent carbon steels rated at 45 tons and 27 tons per sq. in.

Empirical Formulae for the Determination of Stress Curves. E. Voce and A. C. Nicholls. *J. RAeS,* May, 1955, pp. 362–365. Analysis with metallurgical test data.

Investigation into the Load Dependency of Vickers Micro-Hardness. II. H. Bückle. (*Z. für Metallkunde,* Nov., Dec., 1954, pp. 623–632; 694–701.) *Engr. Dig.,* May, 1955, pp. 189–191. 14 refs. Analysis of the influence of rim formation, with test results on copper and aluminum.

Magnetic Measurement of the Hardness of Metals. I, II, III. D. Hadfield. *Metal Treatment,* Mar., Apr., May, 1955, pp. 91–96; 153–159; 219–224. A 20-year developmental review of techniques, instrument designs, metallurgical and applicational principles to determine hardness values as used in the nondestructive testing of ballistic armor-piercing shot.

Radioisotopes as Design Tools. Arthur M. Smith. *Prod. Eng.,* May, 1955, pp. 129–135. Applications include materials testing of castings, sheet-metal thicknesses, engine-exhaust activity, oil contamination, piston-ring wear, and filter efficiency.

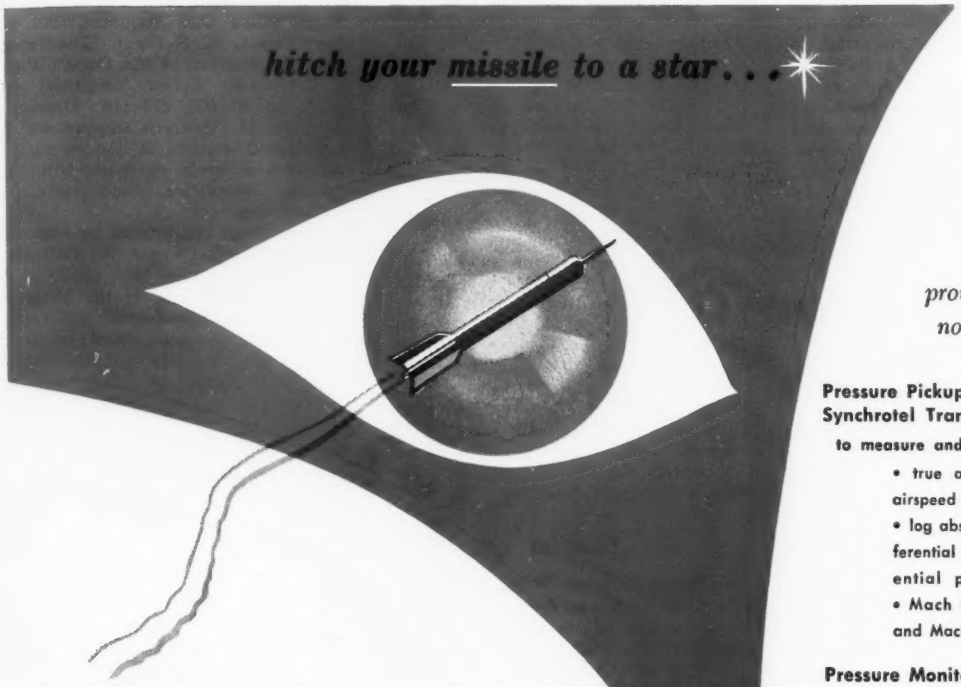
Some Observations on Loss of Static Strength Due to Fatigue Cracks. Walter Illg and Herbert F. Hardrath. *U.S., NACA RM L55D15a,* May 20, 1955. 8 pp. Experimental tests on four types of aluminum alloy crack specimens under various conditions; includes results of static tests on C-46 wings.

Mathematics

Die Ausnutzung zusätzlicher Vorkenntnisse für die Einschliessung von Eigenwerten beim Iterationsverfahren. E. Kreyszig. *ZAMM,* Mar., 1955, pp. 89–95. In German. Use of the Weilandt theory with a Hermitian matrix and iterative techniques to determine eigenvalues.

L'Exploitation des Données Empiriques; Actes du Colloque Tenu à Luxembourg en Juillet 1953 dans le Cadre du Congrès de l'Association Française pour l'Avancement des Sciences. Pierre Vernotte. *France, Min. de l'Air NT 52,* 1955. 77 pp. In French. Analytical methods to utilize empirical data as presented at the 1953 Luxembourg Conf. of the French Assn. for the Advancement of Sci. Contents: Interpolation et Extrapolation Basées sur la Méthode des Moindres Carrés, S. Arend. Détermination des Paramètres de la Fonction $y = a + bf(x, \alpha, \beta \ldots)$, J. Dommanget. Étude des Droites Caractérisant

hitch your missile to a star . . .



Navigation and Control Devices PRODUCED for Missiles and Aircraft

Kollsman has designed, developed and produced the following navigation and control systems and components:

FOR NAVIGATION OR GUIDANCE

CLASSIFIED **Photoelectric Sextants** for remote semi-automatic celestial navigation.

CLASSIFIED **Automatic Astrocompasses** for precise automatic celestial directional reference and navigation.

Photoelectric Tracking Systems For many years Kollsman has specialized in high precision tracking systems.

Periscopic Sextants for manual celestial observations.

CLASSIFIED **Computing Systems** to provide precise data for automatic navigation and guidance, operated by optical, electromechanical, and pressure sensing components.

SAN FRANCISCO, CALIF.
VISIT US IN
BOOTHS 1621 • 1622

FOR CONTROL

proven components now in production

Pressure Pickups and Synchrotel Transmitters to measure and electrically transmit • true airspeed • indicated airspeed • absolute pressure • log absolute pressure • differential pressure • log differential pressure • altitude • Mach number • airspeed and Mach number.

Pressure Monitors — to provide control signals for altitude, absolute and differential pressure, vertical speed, etc.

Acceleration Monitors — for many applications now served by gyros.

Pressure Switches — actuated by static pressure, differential pressure, rate of change of static pressure, rate of climb or descent, etc.

Motors — miniature, special purpose, including new designs with integral gear heads.

SPECIAL TEST EQUIPMENT optical and electromechanical for flight test observations.

Please write us concerning your specific requirements in the field of missile or aircraft control and guidance. Technical bulletins are available on most of the devices mentioned.

kollsman INSTRUMENT CORPORATION

80-14 45th AVE., ELMHURST, NEW YORK • GLENDALE, CALIFORNIA • SUBSIDIARY OF *Standard* COIL PRODUCTS CO. INC.

Soit une Liaison Fonctionnelle, Soit une Dépendance Statistique entre Deux Variables, J. Dommanget. Détermination de la Fonction Homographique à Partir de Données Expérimentales en Surnombre, les Abscisses Étant en Progression Arithmétique, A. Schmitt. Représentation d'une Série Expérimentale par une Foction de la Forme $y = a + be^{ax}$, A. Schmitt. Intégration Numérique entre 0 et 1, de l'Équation Paramétrique du Second Ordre $y'' + \lambda(2 - x^2)\,y = 0$, avec les Conditions aux Limites $\left\{ \begin{matrix} y\ (0) = 0 \\ 2y(1) + y'(1) = 0 \end{matrix} \right\}$, A. Ziller. Le Vrai Problème, P. Vernotte.

Méthodes de Différentiation et d'Intégration Numériques (Applications). I—Differentiation Numerique. II—Intégration Numérique. A. Ziller. *France, Min. de l'Air NT 50*, 1955. 150 pp. In French. Study of analytical methods of numerical differentiation and integration, including: a proposition relative to the complementary term of a development of function in a Taylor series; inverse and normal interpolation; extrapolation; equidistant reduction; calculations of a defined simple integral and double integrals; and numerical resolution of differential equations.

Some Statistical Methods for Evaluation of Experimental Results. E. W. Pike. *Trans. ASME*, May, 1955, pp. 401–403.

Über die Faktorisation von Matrizen und ihre Anwendung auf die Lösung von linearen Gleichungssystemen. E. Egerváry. *ZAMM*, Mar., 1955, pp. 111–118. In German. Development of a practical logarithm of factorization to reduce a homogeneous system of linear equations to an equivalent system of linearly independent equations through a breakdown of the matrix of the coefficients into two basic factors.

Discrete Approximations to Elliptic Differential Equations. Wolfgang Wasow. *ZAMP*, Mar. 25, 1955, pp. 81–97. 22 refs. ONR-sponsored study.

Mixed Problems for Hyperbolic Partial Differential Equations. L. L. Campbell and A. Robinson. *Proc. London Math. Soc., 3rd Ser.*, May, 1955, pp. 129–147.

Singular Perturbation of Eigenvalue Problems for Linear Differential Equations of Even Order. Jürgen Moser. *Comm. on Pure & Appl. Math.*, May, 1955, pp. 251–278. 20 refs. ONR-sponsored study.

Linear Functions with Domain a Real Countably Infinite Dimensional Space. R. Henstock. *Proc. London Math. Soc., 3rd Ser.*, May, 1955, pp. 238–256.

On Certain Integrals of Lipschitz-Hankel Type Involving Products of Bessel Functions. G. Eason, B. Noble, and I. N. Sneddon. *Philos. Trans. Royal Soc. (London), Ser. A*, Apr. 19, 1955, pp. 529–551. 15 refs.

Mechanics

On the Derivation of the Equations of Hydrodynamics from Statistical Mechanics. Charles B. Morrey, Jr. *Comm. on Pure & Appl. Math.*, May, 1955, pp. 279–326. ONR-supported research at the U. of Calif.

Meteorology

Reconnaissance of the "Complete Hurricane." Leon Sherman and Noel E. LaSeur. *Bul. AMS*, Apr., 1955, pp. 152–158. USAF-supported study, with flight observations to locate the hyperbolic point as well as the "eye" of the hurricane at Patrick AFB, Fla.

Military Aviation & Armament

How Impenetrable Is the Iron Curtain? Outline of the Organization and Production of the Russian Aircraft Industry. *Interavia*, No. 5, 1955, pp. 324–330. Military strength survey, including a descriptive tabular breakdown of fighters, bombers, and "uncomfirmed" types.

Special Issue: Military Aviation. *Flight*, May 13, 1955. 166 pp. Partial contents: The World's Air Forces; Their Composition, Duties, and Aircraft. The World's Military Aircraft 1955.

Missiles

Guidance Systems, Weapons & Controls. *The Aeroplane*, May, 20, 1955, pp. 655–680. Partial contents: Britain's Guided Weapon Industry. Current Progress in Guided Weapons. Guided Weapons of the World (Data Assembled from Published Information). G. W. Propulsion Systems. Flying Control Systems. Radio Navigational Aids.

Guided Missile Control; A Synoptic Review of Methods and Requirements. *Bristol Quart.*, Spring, 1955, pp. 157–160.

Guided Missiles and Rockets. *Interavia*, No. 5, 1955, pp. 299–323. Partial contents: The State of the Art, James Fenton Smith. Long-Range Missiles Will Make Peace Unavoidable. I—The Military Aspect. II—The Technical Aspect. Guided Missiles for Home Defence, H. Aldinger. The Rocket-Driven Commercial Airliner, Walter R. Dornberger.

Instrumentation of the Rocket-Grenade Experiment for Measuring Atmospheric Temperature and Winds. W. G. Stroud, E. A. Terhune, J. H. Venner, J. R. Walsh, and S. Weiland. *Rev. Sci. Instr.*, May, 1955, pp. 427–432. Details of the Aerobee Rocket Project at the White Sands Proving Ground, with ballistic and performance data and descriptions of the grenade structure, flash detectors, the FM/FM telemetering system, safety features, and sound-ranging ground equipment.

Practical Development of Suspension Cushioning for a Guided Missile. R. L. Wiltse. *SAE Golden Anniv. Aeronautic Meeting, New York, Apr. 18–21, 1955, Preprint 498*. 13 pp. Protective measures against transit, storage, and environmental loads and conditions.

Navigation

The Accuracy of Dead Reckoning in the Air. Appendix I—The Total Error in D. R. Position. Appendix II—To Obtain the Standard Error of Wind Over a Leg of a Route When the Wind at One End Is Used as a Forecast. Appendix III—A Method of Obtaining the Standard Navigational Error of Aircraft Flying on Long Routes. Appendix IV—Procedure for Obtaining the Probable Wind Over the Next Leg of a Flight When One Accurate Wind Has Been Found. C. S. Durst. **The Navigational Implications of Mr. Durst's Paper.** J. B. Parker. *J. Inst. Navigation*, Apr., 1955, pp. 91–109, 113–116; Discussion, pp. 109–113. Analysis emphasizing meteorological aspects of the operational problems of errors concerned with wind finding, forecasting, and instrument shortcomings.

The Newest Instruments for Astonomical Navigation. Victor E. Carbonara. *Aero. Eng. Rev.*, July, 1955, pp. 36–39, 54. Design and operation of the photoelectric sextant for the automatic performance of sighting, averaging, and presenting celestial reference data on a single control panel.

Noise Reduction

Instrumentation for Noise Measurements. William B. Snow. *Noise Control*, May, 1955, pp. 16–21, 56. A comprehensive review of analytical measuring techniques and apparatus for different types of noise; applications.

Investigation of Jet-Engine Noise Reduction by Screens Located Transversely Across the Jet. Edmund E. Callaghan and Willard D. Coles. *U.S., NACA TN 3452*, May, 1955. 27 pp. 10 refs.

Measurements of Free-Space Oscillating Pressures Near a Propeller at Flight Mach Numbers to 0.72. Arthur W. Vogeley and Max C. Kurbjun. *U.S., NACA TN 3417*, May, 1955. 24 pp. Analysis of the effects of the near-field noise problem.

Parachutes

A Repeating Parachute. Appendix A—Predicting Rotary Behaviour in a Drop by Means of Low Speed Towing Tests. H. T. Stevinson and P. Mandl. *CAI 1st Annual Meeting, Toronto, May 19, 20, 1955, Preprint.* 46 pp. Design, development and operational characteristics of a stable self-controlling type that opens and closes itself repeatedly.

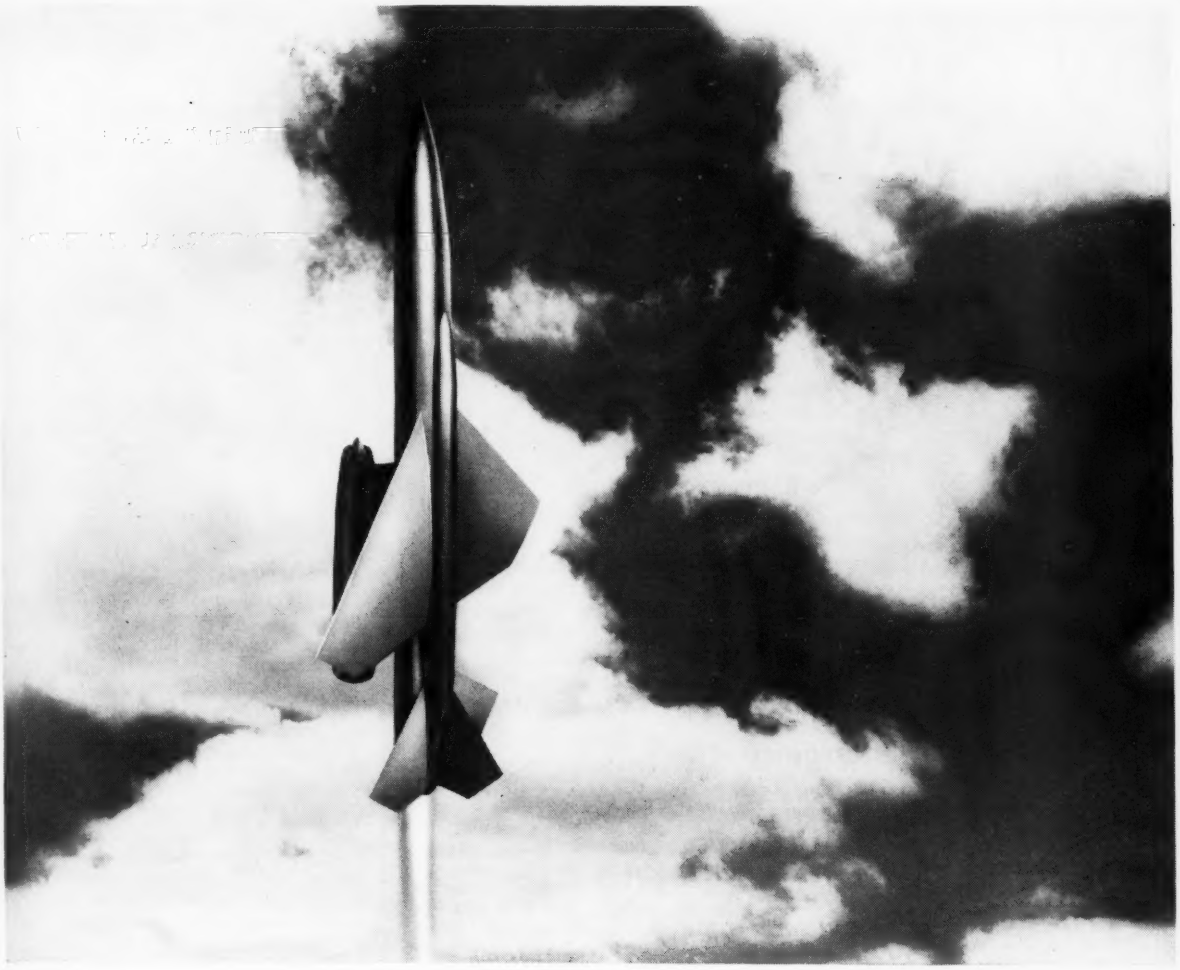
Photography

Aerial Survey Operations. J. Fleming. *CAI 1st Annual Meeting, Toronto, May 19, 20, 1955, Preprint.* 14 pp. Developmental review of the airborne phase.

Kerr-Cell Shutter Has Submicrosecond Speed. William Q. Nicholson and Irving Ross. *Electronics*, June, 1955, pp. 171–173. Development of an electro-optical shutter suitable for photography of short-duration luminous phenomena as in explosion and ballistic studies.

A Photographic Instrument for Flight Path Analysis. Karl J. Fairbanks. *Photographic Eng.*, No. 1, 1955, pp. 1–10. Design and operational factors as applied to the study of aircraft performance, landing gear impact velocities, missile trajectories, bird flight, and sinking paths of helicopters at various gross weights with engine failure.

A Small Stroboscopic Photo-Instrument. *Photographic Eng.*, No. 1, 1955, pp. 11–19. Operating principles; application to the study of ultra-rapid phenom-



Boeing "Aeros" have a date with the future

Guided missiles like this Boeing Bomarc IM-99 are increasingly important in America's defense planning. Boeing aeronautical engineers are gaining knowledge that will be priceless in producing the hypersonic vehicles and missiles of the future. These men explore the frontiers of engineering knowledge in aerodynamics, structural and flight testing, vibration, flutter, plasticity, elasticity and many other fields.

Boeing aeronautical engineers are members of aviation's top creative team. They are now working on projects in supersonic flight, rocket, ram jet and nuclear propulsion, guided missiles, and much more. The aircraft they create will maintain the leadership and prestige established by the Boeing B-47 . . . the B-52 . . . the Bomarc IM-99 . . . and, most recently, the KC-135, America's first all-jet tanker-transport.

At Boeing, engineers' professional achievements are recognized by regular merit reviews and in other ways. The Boeing policy is to promote from within the organization. And Boeing is known as an "engineers' company." One out of every seven employees is an engineer! Among top management, the proportion is even higher.

Equipment at Boeing is superb: the latest electronic computers, a chamber that simulates altitudes up to 100,000 feet, splendidly equipped laboratories, and the new multi-million-dollar Flight Test Center. The world's most versatile privately owned wind tunnel, at Boeing, is soon to be supplemented by a new tunnel capable of velocities up to Mach 4.

Do you want a career with one of America's most solidly growing companies? Do you want a chance to grow, and to share in the challenging future of flight? Then there's a place for *you* on one of Boeing's engineering teams in design, research or production.

JOHN C. SANDERS, Staff Engineer—Personnel
Boeing Airplane Co., Dept. A-42, Seattle 14, Wash.

Please send further information for my analysis. I am interested in the advantages of a career with Boeing.

Name_____

University or college(s) _____ Year(s) _____ Degree(s) _____

Address_____

City_____ Zone_____ State_____

DEPARTMENT OF TECHNOLOGY ERIE COUNTY PUBLIC

BOEING

Aviation leadership since 1916

SEATTLE, WASHINGTON WICHITA, KANSAS

ENGINEERING OPPORTUNITIES *for you!*

CONVAIR-Pomona is engaged in development, engineering and production of electronic equipment and complex weapons systems. The Convair-Pomona engineering facility is one of the newest and best equipped laboratories in the country. The work in progress, backed by Convair's outstanding record of achievement, offers excellent opportunities for recent graduates and experienced engineers in the following fields:

ELECTRONICS
DYNAMICS
AERODYNAMICS
THERMODYNAMICS
OPERATIONS RESEARCH
HYDRAULICS
MECHANICAL DESIGN
LABORATORY TEST ENGINEERING

Generous travel allowance to engineers who are accepted.

*For further information on Convair and its fields of interest, write at once, enclosing a complete resume to:
Employment Department 3-N

*ENGINEERING BROCHURE TO QUALIFIED APPLICANTS

CONVAIR
A DIVISION OF GENERAL DYNAMICS CORPORATION
POMONA, CALIFORNIA

ena of a periodic and aperiodic nature such as vibration dynamics, flow of liquids and gases, combustion processes, and electrical discharges.

Power Plants

A Combustor Analysis Method Envolved from Basic Flame Stability and Fuel Distribution Research. John W. Bjerklie. *Jet Propulsion*, May, 1955, pp. 227–231, 234. Application to the development of burner systems in turbojets, afterburners, rockets, and ramjets.

Development of a Compression Apparatus and Studies on Heat Transfer and Combustion of Rapidly Compressed and Oscillating Gases. II. H. A. Havemann. *J. Indian Inst. Sci., Sect. B*, Apr., 1955, pp. 121–137. Analytical investigation of the combustion processes at the Inst. for Aero Engine Technics, Brunswick Tech. U. and at the Res. Estab. for Aeronautics, Völkenrode, W. Germany; includes calculations of motion of piston and the resulting gas pressure.

Jet & Turbine

The Allison T56 Turbo-Prop Aircraft Engine. John B. Wheatley, D. G. Zimmerman, and R. W. Hicks. *SAE Golden Anniv. Aeronautic Meeting, New York, Apr. 18–21, 1955, Preprint 500.* 21 pp. Design, performance, testing requirements, and developmental problems.

Analyzing a Typical, Simple-Cycle Turbo-Jet Design and Development Program. Merrill G. Hinton, Jr., and John M. Wetzler. *GM Eng. J.*, May–June, 1955, pp. 16–21, cutaway drawing. Evaluation of mechanical, thermodynamic, aerodynamic, control, and testing problems affecting the overall engine design and other critical requirements to obtain an optimum and efficient program.

Ist eine entscheidende Senkung der Verbrauchszahlen der heutigen Luftstrahltriebwerke noch möglich? M. A. Müller. *ZFW*, May, 1955, pp. 113–118. In German. Utilization suitability factors in selecting turbojets based on the principle of constant volume as opposed to constant pressure to improve the figure of consumption with increased economy of operation.

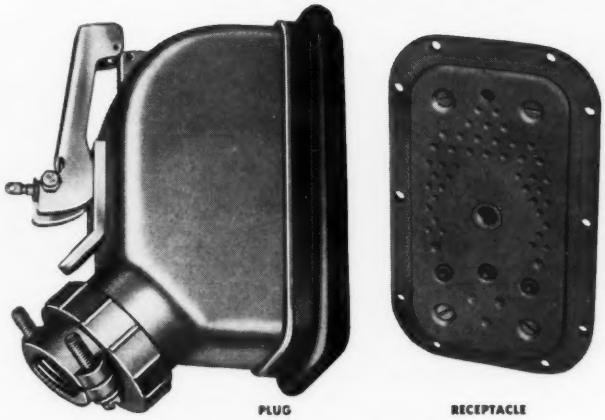
An Analogue Study of the Temperature Distribution in Cooled Gas-Turbine Blades. C. F. Kettleborough. *Brit. J. Appl. Phys.*, May, 1955, pp. 174–176.

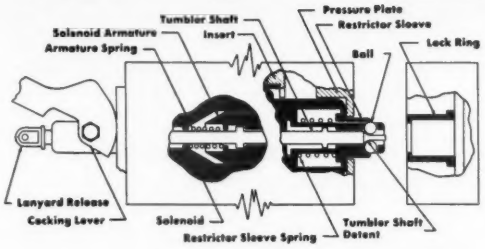
Pitch Errors of the Serrations of Gas Turbine Blades. L. W. Nickols. *The Engr.*, May 20, 1955, pp. 692–694. NPL design and construction of a comparator for high-speed measurements of blade tolerances of the order of ± 0.00005 in.

Propagation à Faible Vitesse d'une Flamme dans un Écoulement Compressible. G. Ernst. *Tech. et Sci. Aéronautiques*, No. 1, 1955, pp. 1–12. In French. Study of the mechanism of propagation and stabilization of a flame in a compressible flow at low speeds; application to turbojet combustion processes.

Small Turbojet Engines—A Big Factor in Aviation. A. T. Gregory. *SAE Golden Anniv. Aeronautic Meeting, New York, Apr. 18–21, 1955 Preprint 499.* 14 pp. Basic characteristics and relative merits in terms of the factors of utility, reliability, durability, and expendability.

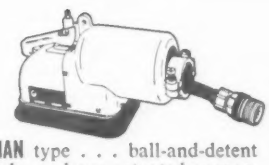
for guided missiles... CANNON PLUGS





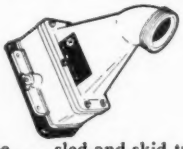
Cannon's Type GMA Plug and Receptacle, equipped with 45 degree endbell. Available either with remote solenoid disconnect mechanism or manual lanyard release. A ball-and-detent type breakaway plug, accommodating from 41 to 140 contacts, ranging in wire size from 0 to #16.

Cannon's type "GM" Guided Missile Connectors, available in more than 10 basic shell designs and a wide variety of disconnect systems, are engineered for guided missile launching under ordinary and hazardous conditions. Built for heavy service duty with shells of durable aluminum alloy and inserts of melamine or laminated phenolic, these sturdy connectors have a maximum current rating of 200a and a nominal flashover value of 5,000v, more than 22 contact layout arrangements accommodating from 8 to 140 contacts. Co-axial, thermocouple or high-current-capacity contacts are available. Many types of Cannon Plugs are used in rocket and missile components. The "GM" Series extends Cannon's policy of complete and comprehensive connector service into the launching phase of guided missile development.



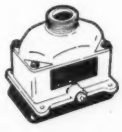
GMAN type . . . ball-and-detent latch . . . lever actuated engagement . . . solenoid or manual release . . . high current contacts and 90 degree angle endbell. Two contact layouts.

GMC type . . . ball-and-detent latch . . . handwheel actuated engagement . . . remote solenoid or manual disconnect . . . equipped with 45 degree endbell. Three contact layouts.

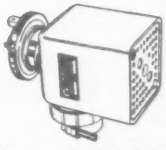


GMD type . . . sled-and-skid type connector for rack launching . . . skid-way type disconnect . . . longitudinal mounting brackets . . . 60 or 90 degree endbells. Two contact layouts.

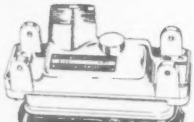
GMDA type . . . sled-and-skid type connector for rack launching . . . lateral mounting brackets . . . skid-away release mechanism . . . straight or 60 and 90 degree endbells. Six contact layouts.



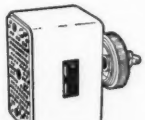
GMDD type . . . sled-and-skid type connector for platform launching . . . straight endbell . . . longitudinal mounting ears . . . 22 size 14 contacts. One contact layout.



GME type . . . ball-and-detent type latch . . . handwheel engagement . . . manual release only . . . handwheel equipped with ears for clevis . . . 90 degree angle endbell. Seven contact layouts.



GMJ type . . . sled-and-skid type connector for platform launching . . . manual fall-away disconnect . . . mounting ears fitted on rear . . . 30 degree angle endbell. One contact layout.



GMK type . . . ball-and-detent latch . . . handwheel engagement . . . with or without ears for clevis . . . manual release only . . . 90 degree angle endbell. Two contact layouts.

GME type . . . ball-and-detent latch, handwheel actuated engagement, manual lanyard release only. 90 degree endbell. One contact layout.

Refer to Dept. 105

CANNON ELECTRIC COMPANY, 3209 Humboldt St., Los Angeles 31, California. Factories in Los Angeles; East Haven; Toronto, Canada; and London, England. Representatives and distributors in all principal cities.

Since CANNON ELECTRIC 1915

CANNON ELECTRIC

In addition to the "GM" Series, Cannon Types "AN", "K", "DPD", miniature connectors, and the J06 are used for missiles and jettisonable equipment. For an overall survey of these, request your copy of the "Cannon Plug Guide". For complete engineering data on the "GM" rocket launching connectors request the "GM" Bulletin on company letterhead.

The Supercharged Turbo Prop. S. G. Hooker. *SAE Golden Anniv. Aeronautic Meeting, New York, Apr. 18–21, 1955, Preprint 487.* 15 pp. Design concept of the Bristol B.E.25 Turbo Prop Engine, with an analysis of thermo- and aerodynamic factors and performance.

Before Afterburners. Frank F. Rand, Jr. (*IAS 23rd Annual Meeting, New York, Jan. 24–27, 1955, Preprint 531.*) *Aero. Eng. Rev.*, July, 1955, pp. 32–35. Development of a cruise engine design and evaluation of the relative merits of thrust augmentation in adding heat to a basic engine in an afterburner or high-temperature combustor upstream of the turbine.

Les Variateurs Auxiliaires de la Poussée des Turboréacteurs. Pierre Ph. Chaffiotte. *Tech. et Sci. Aéronautiques*, No. 1, 1955, pp. 30–42. In French. Analysis of the thrust augmentation problem of turbojets, afterburner requirements, and the merits of water-methanol injection techniques in terms of performance parameters.

Reciprocating

L'Apport des Moteurs à Pistons dans l'Évolution de la Technique des Machines Thermopropulsives d'Aviation. I—Introduction. R. Marchal. **Amélioration de la Tenue à la Fatigue et à la Corrosion des Ressorts de Soupapes de Moteurs à Pistons.** R. Chevalier. **III—Amélioration de la Conductivité Thermique des Cylindres de Moteurs à Refroidissement.** R. Wellard and R. Delmas. *Tech. et Sci. Aéronautiques*, No. 5, 1954, pp. 347–362. In French. Contributions of piston engines in the evolution of thermopropulsive machine techniques in aviation; analyses include the factors of high-temperature alloys, fatigue, corrosion, heat transfer, cooling, fabrication, and testing.

Rocket

Die Erfoschung der Initialvorgänge bei Verbrennungsprozessen. Irene Sänger-Bredt. *Astronautica Acta*, Fasc. 1, 1955, pp. 3–31. 152 refs. In German. Analytical review of experimental methods used to study basic combustion processes of chemical and nuclear reactions for rocket propulsion.

Mixture Ratio and Temperature Surveys of Ammonia-Oxygen, Rocket Motor Combustion Chambers. Appendix—Construction and Use of the Pneumatic Thermometer and Gas-Sampling Probe. Dwight I. Baker. *Jet Propulsion*, May, 1955, pp. 217–226, 234. 14 refs. NavBuAer-sponsored investigation at the CIT Jet Propulsion Lab.

The Prospects and Problems of Rocket Propulsion for Aircraft. A. D. Baxter. *J. RAeS*, May, 1955, pp. 315–332; Discussion, pp. 332–336; Author's reply, pp. 336–338. Analytical and developmental survey of design and performance factors related to starting, thrust control, thrust-weight ratios, acceleration and speed, and fuel supply of rocket motors used for auxiliary assisted take-off and climb-boosting or as the main power plant; comparative evaluation of air-swallowing types of engines and rocket-ramjet duct design combinations.

Rocket Engines and Propellants. A. V. Cleaver. *J. Brit. Interplanetary Soc.*, May-June, 1955, pp. 154–158. Fundamental characteristics of reaction propulsion power plant systems and the relative merits and potentialities of the fuels required.

Production

Metalworking

A Design Guide to Production Characteristics of Engineering Metals. *Mach. Des.*, May, 1955, pp. 156–231. Comprehensive analyses of basic properties, applications, and fabricational procedures. Contents: Wrought Carbon and Alloy Steel. I—Drawing Properties. Carter C. Higgins. II—Machinability. Francis W. Boulger. III—Weldability. Helmut Thielsch. IV—Forging Characteristics. V—Cold Heading Properties. David H. Samuelson. VI—Hot Extrudability. Clark Church. Wrought Stainless Steel—Machinability, Hot and Cold Working, Forging, Cutting and Shearing, Stamping, Deep Drawing, Welding, Brazing, Soldering, Finishing. Basil T. Lanphier. Gray Iron—Castability, Section Sensitivity, Machinability, Finishing, Specifications. C. F. Walton. Malleable Iron—Castability, Tolerances, Machinability, Standards. James H. Lansing. Cast Steel—Castability, Tolerances, Weldability, Machinability. Charles W. Briggs. Cast Stainless Steel—Machinability, Welding Procedures, Heat Treatment. E. A. Schoefer. Brass, Bronze and Copper—Stamping, Drawing, Shearing, Forming, Bending Cold and Hot Forging, Heading, Upsetting, Machinability. Arthur I. Heim. Wrought Aluminum Alloys—Heat Treatment, Cold Forming, Machinability, Extrusion, Forging, Welding, Brazing, Soldering, Finishing. T. F. McCormick. Cast Aluminum Alloys—Castability, Machinability, Weldability, Finishing. G. W. Birdsall. Magnesium Alloys—Castability, Formability, Machinability, Weldability, Finishing Characteristics. Paul L. Filter.

Fabrication of Titanium Components. Arnold S. Rose. *Jet Propulsion*, May, 1955, pp. 212–216, 234. Forming, forging, spinning, and welding procedures used for gas turbine, missile, or rocket assembly.

Precision Contour Rolling Teams With Welding To Produce Steel Propellers. A. E. Felt. *Steel Processing*, May, 1955, pp. 305–309. A. O. Smith Corp.'s Aero. Div. metalworking and fabricational procedures for high-efficiency and high-strength blades.

Review of Surface Finish Literature. John W. Sawyer. *Mach. Des.*, May, 1955, pp. 155 ff. (4). 120 refs. Bibliographical coverage for 1952–1953, with brief abstracts.

Adhesive Bonding. Jerome L. Been. *Prod. Eng.*, May, 1955, pp. 181–186. Selection, design specifications, and other factors for correct formulation and processing in particular applications.

Studien zum Metallkleben. Hermann Winter. *ZFW*, Mar.–Apr., 1955, pp. 87–94. In German. Results of metal-bonding static and dynamic tests using Redux, Araldite, and other adhesives.

Contribution to the Knowledge of Pressure Measurements During Metal Deformation. J. Frisch. *Trans. ASME*, May, 1955, pp. 509–513. Experimental pressure and stress measurements using SR-4 strain gages during the forming processes of forging, rolling, extruding, and metal cutting.

Controlled Stretch-Forming; A Method of Producing Consistent Workpieces by Means of a Servo-Control System. *Aircraft Prod.*, June, 1955, pp. 234–236.

A New Approach to Metal-Forming Problems; Experimental Stress Analysis for a Tubular Extrusion. E. G. Thomsen. *Trans. ASME*, May, 1955, pp. 515–522.

Two Decades of Progress in Drop Forging. I. H. J. Merchant. *Metal Treatment*, May, 1955, pp. 211–218. 15 refs. Developmental review with emphasis on materials, metallurgical aspects, and plant and equipment requirements.

Upset Forgings; Modern Methods and Design. I. M. W. Lamprecht. *Steel Processing*, May, 1955, pp. 295–304.

Nonmetalworking

When to Use Vacuum-Formed Plastics. Carl H. Bagen. *Mach. Des.*, May, 1955, pp. 149–152. Basic factors of molding and forming techniques.

Production Engineering

The Economical Production of Jet Engines in Canada. E. K. Brownridge. *CAI 1st Annual Meeting, Toronto, May 19, 20, 1955, Preprint.* 28 pp. Orenda problems, facilities, and techniques based on experience data.

Blade-Root Inspection; A New Comparator for Measuring the Pitch Errors of Turbine-Blade Fir-Tree Serrations. L. W. Nickols. *Aircraft Prod.*, June, 1955, pp. 212–214.

Hardenability Evaluation of Welding Electrodes. Leo M. West. *Welding J.*, May, 1955, pp. 399–404. Aircraft fabricational experience with inspection test procedures and results after heat treatment.

Oscillographic Instruments in Spot Welding Quality Control and Maintenance. Glenn Woodmancy. *Welding J.*, May, 1955, pp. 425–432.

Selecting Effective Gear Inspection Methods. Fred Bohle. *Tool Engr.*, June, 1955, pp. 111–114. Abridged. Analytical procedures and apparatus to obtain maximum uniformity and control of output.

Statistical Quality Control. IX—Significance. Gilbert L. Peakes. *SPE J.*, May, 1955, pp. 11–13, 16–18, 24.

Tooling

Economy of Tooling. R. J. Higman. *CAI 1st Annual Meeting, Toronto, May 19, 20, 1955, Preprint.* 5 pp. Recommendations for an aircraft tooling philosophy to utilize more effectively established fabricational skills and techniques thus reducing costs of production.

Turret Machining; The Development of the Schiess Vertical Turret Lathe with Pre-Selective Equipment for Sequence-Control Operation. *Aircraft Prod.*, June, 1955, pp. 237–241.

Welding

Fatigue Aspects in Aircraft Welding Design. J. Koziarski. *Welding J.*, May, 1955, pp. 446–458. 77 refs.

46 Major Projects at Lockheed

Advance Careers of Engineers

Lockheed projects cover virtually the entire spectrum of aeronautical engineering endeavor, including turbo-prop, turbo-compound and jet transports; jet fighters, trainers and bombers; vertical rising aircraft; nuclear applications to aircraft and many other significant classified activities.

It is the largest development and production program in the company's history, with 13 models already on assembly lines.

Diversification such as this offers engineers:

- More opportunity for promotion—because there are more high echelon positions to be filled on such a large number of projects.
- More career security—because Lockheed activities span so many phases of aeronautical effort.
- More stimulating work—because there is a wider range of assignments, because engineers have more scope for their ability, because a firm active on so many fronts of aviation welcomes and rewards fresh thinking, new ideas.

Generous travel and moving allowances enable you and your family to join Lockheed at virtually no expense to yourself. Lockheed Employe Service helps you get settled when you arrive.

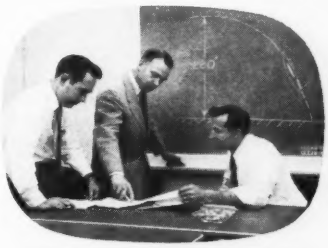
Immediate Openings for: AERODYNAMICS ENGINEERS • AIRBORNE ANTENNA RESEARCH ENGINEERS • DESIGN ENGINEERS — at all levels in mechanical, electrical, hydraulic, power plant, controls and structures fields. • FLIGHT TEST ANALYSIS ENGINEERS • MATH ANALYSTS — to work on Lockheed's two 701 Digital Computers MICRO-WAVE SPECIALISTS—with at least three years' direct experience in an advisory capacity on airborne radar applications as well as a broad theoretical background and an advanced degree in Electronics or Physics • OPERATIONS RESEARCH SCIENTISTS • STRESS AND STRUCTURES ENGINEERS • STRUCTURES RESEARCH ENGINEERS • THERMODYNAMICS ENGINEERS • WEIGHT ENGINEERS.

A report on "High Heat Treat Steel" taken from one of Lockheed's monthly engineering and manufacturing forums is available to interested engineers. Address requests to the forum chairman, E. H. Spaulding.

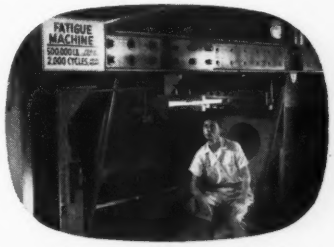
Engineers interested in Lockheed's expanding development and production program are invited to write to E. W. Des Lauriers, Dept. MP-5-8.

Below: Lockheed engineers at work on various projects

Operations Research study on overseas transport routes



Aerodynamic meeting on high-speed fighter



Fatigue test on Super Constellation skin

Antenna pattern study on radar search plane

Design study on hydraulic requirements of new transport

Lockheed

AIRCRAFT CORPORATION

CALIFORNIA DIVISION • BURBANK

California

Fusion Welding Unalloyed Titanium Sheet Without Filler Rod. Alan V. Levy and Robert Wickham. *Welding J.*, May, 1955, pp. 413–419.

Spot Welding of Light Alloys. J. E. Roberts. *Brit. Welding J.*, May, 1955, pp. 193–199. 16 refs. General appraisal of procedural, equipment, and surface condition requirements for aluminum.

Structural Spotwelding; Applications in Airframe Manufacture to Large Fuselage Skin-Panels and Floor Structure. William R. Cain. *Aircraft Prod.*, June, 1955, pp. 242–247.

Propellers

Caratteristiche delle Eliche a Giri Costanti (Features of Constant Speed Airscrews). B. Rocchi. *L'Aerotecnica*, Feb. 1955, pp. 22–25. In Italian. Operation and design featuring sensitiveness and stability.

Näherungsweise Berechnung des ummantelten Propellers. Wilhelm Seibold. *ZFW*, May, 1955, pp. 130–133. In German. Calculation based on the Froude theory to derive a simple formula for the static thrust of a ducted propeller.

Reference Works

Research and Development Technical Planning Handbook. *Av. Age*, June, 1955. 376 pp. Features include: Cost parameters of a weapon system; missile experimentation; aerodynamics and fluid mechanics; aircraft designs, including fixed-wing, rotary-wing, and water-based types; aircraft guidance, traffic control, and instrumentation; electronic, pneumatic, hydraulic, electro-mechanical, refrigeration, and air conditioning accessory systems; metals, alloys, and nonmetallic materials; production engineering; test-training research equipment, including computers and simulators; list of prime contractors; and airport, heliport, and aviation operations.

Review of Surface Finish Literature. John W. Sawyer. *Mach. Des.*, May, 1955, pp. 155 ff. (4). 120 refs. Bibliographical coverage for 1952–1953, with brief abstracts.

Tele-Tech's 1955 Electronic Industries Directory. *Tele-Tech*, June, 1955, pp. 187–370. Features include indexes and listings of products, brand and trade names, consulting engineers and societies, manufacturers, distributors, representatives, and advertisers.

Rotating Wing Aircraft

Bristol Type 173; Design, Development, and Experiences. Raoul Hafner. *J. Helicopter Assn. Gt. Brit.*, Apr., 1955, pp. 158–186; Discussion, pp. 186–191. A descriptive analysis of the characteristics, special features, and performance of the tandem-rotor twin-engined helicopter, including control, transmission, ground resonance, and vibrational factors; comparison with the single-engined Type 171.

A Dynamic-Model Study of the Effects of Added Weights and Other Structural Variations of the Blade Bending Strains of an Experimental Two-Blade Jet-Driven Helicopter in Hovering and Forward Flight. John Locke McCarty and George W. Brooks. *U.S., NACA TN 3367*, May, 1955. 47 pp.

The Helicopter, Present and Future. A. Stringer. *CAI 1st Annual Meeting, Toronto, May 19, 20, 1955, Preprint.* 7 pp. Developmental review of civil and military utilization and potentialities.

The Kaman Hydra-Mechanical Clutch. W. N. Stone and N. R. Richmond. (*IAS 23rd Annual Meeting, New York, Jan. 24–27, 1955, Preprint 531.*) *Aero. Eng. Rev.*, July, 1955, pp. 45–47, 54. Design criteria and operational principles of the clutch and freewheeling unit as applied to the HOK-1 helicopter.

Power Loss and Fuel Pressure Rise due to Centrifugal Pumping in Tip-Driven Helicopter Rotors. P. R. Payne. *J. RAeS*, May, 1955, pp. 360–362.

The Transport Helicopter. (James Clayton Lecture.) Igor I. Sikorsky. *Chartered Mech. Engr.*, May, 1955, pp. 237–248. (Also abridged in *The Engr.*, May 6, 13, 1955, pp. 636, 637, 657–659.) Developmental review of progress in civil and military passenger and cargo operations, of configurational types and engine designs, and of potentialities as compared to other modes of transportation.

Safety

Actuarial Approaches to Safety. Jerome Lederer. *SAE Golden Anniv. Aeronautic Meeting, New York, Apr., 18–21, 1955, Preprint 503.* 23 pp. 25 refs. Statistical approach to the study of the design, weight, reliability, space, cost, maintenance, and other problems of safety requirements.

Performance Standards in Practice. R. E. Gillman. *The Aeroplane*, May 13, 1955, pp. 634–638. Analytical methods of determining airline operational safety margins in terms of fail-safe and reliability parameters.

Safety Factors. R. Cox Abel. *Aeronautics*, May, 1955, pp. 31–33. Analysis of structural design limits to obtain balance between loads and strength for safety criteria.

Theoretical Analysis of Light Plane Landing and Take-Off Accidents Due to Encountering the Wakes of Large Airplanes. Zegmund O. Bleviss. *Douglas Rep. SM-18647*, Dec., 1954. 67 pp. 16 refs.

Space Travel

Optimal Programming of Rocket Thrust Direction. D. F. Lawden. *Astronautica Acta*, Fasc. 1, 1955, pp. 41–56. Theoretical derivation of equations for the general case of a rocket moving in a specified gravitational field subjected to atmospheric resistance, with a solution for the case of a rocket moving in a uniform field; appraisal of methods of escape from a circular orbit using thrust yielding constant acceleration.

Structures

Energy Theorems and Structural Analysis; A Generalized Discourse with Applications on Energy Principles of Structural Analysis Including the Effects of Temperature and Non-Linear Stress-Strain Relations. I—General Theory (Continued). J. H. Argyris. *Aircraft Eng.*, May, 1955, pp. 145–158.

Fatigue Life of Airplane Structures. (The Eighteenth Wright Brothers Lecture.) Bo Lundberg. **Appendix A—Analysis of Damage Intensity and Cumulative Damage.** Sigge Eggwertz. *J. Aero. Sci.*, June, 1955, pp. 349–402; Discussion, pp. 403–413. 64 refs. Technical evaluative survey of prime aspects of the fatigue problem affecting complete aircraft with emphasis on design techniques, operational and safety factors; development of a general formula for the calculation of cumulative damage basic to the determination of fatigue life within probability limits.

The Solution of Plane Stress Problems by an Electrical Analogue Method. G. Liebmann. *Brit. J. Appl. Phys.*, May, 1955, pp. 145–157. 16 refs. Principles of a cascaded resistance network technique to solve the $\nabla^4 \chi = 0$ biharmonic equation in stress analysis and the $\nabla^4 w = f(x, y)$ type as in the elastic bending and extension of flat plates.

Bars & Rods

O Niesprężystym Wyboczeniu Prętów Pryzmatycznych (The Non-Elastic Buckling of Prismatic Bars). Michał Broszko. *Arch. Mech. Stosowanej* (Warsaw), No. 7, 1955, pp. 24–33. In Polish, with summaries in English and Russian. Theoretical and experimental investigation.

Problems Connected with the Rhombus. II—Plastic Torsion. K. T. Sundara Raja Iyengar and S. K. Lakshmana Rao. *J. Indian Inst. Sci., Sect. B*, Apr., 1955, pp. 113–120. Use of a relaxation technique to obtain a numerical solution for the case of a uniform isotropic bar with rhombus cross-section.

Cylinders & Shells

Preliminary Investigation of the Failure of Pressurized Stiffened Cylinders. Norris F. Dow and Roger W. Peters. *U.S. NACA RM L55D15b*, May 20, 1955. 14 pp.

Wyboczenie i Drgania Własne Powłoki Walcowej (Buckling and Free Vibrations of a Cylindrical Shell). Witold Nowacki. *Arch. Mech. Stosowanej* (Warsaw), No. 7, 1955, pp. 111–131. In Polish, with summaries in English and Russian.

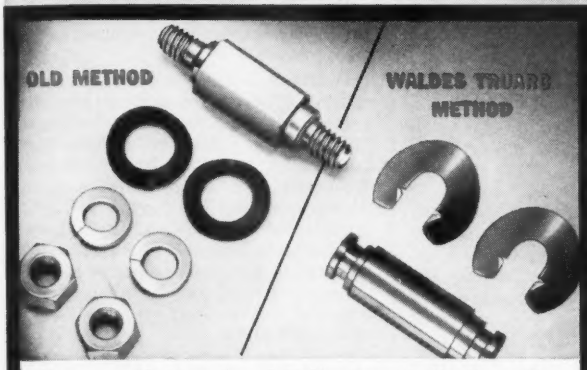
Elasticity & Plasticity

L'Analogia del Prof. C. L. Ricci e gli Studi Sperimentali sui Telai Elastici (The Ricci Analogy, and the Experimental Stress Analysis of Elastic Frames). Guido Guerra. *L'Aerotecnica*, Feb., 1955, pp. 11–16. 10 refs. In Italian. Analytical application of the analogy between displacements and resultants of stresses of two frames.

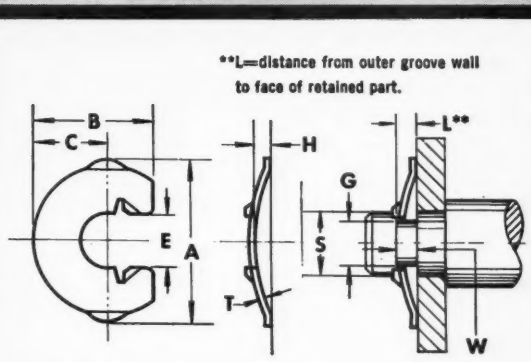
Funkcje Naprężeń dla ciał Sprężystych o Ortotropii Trójosiowej (Stress Functions for Elastic Bodies with Three-Axial Orthotropy). Zofia Mossakowska. *Arch. Mech. Stosowanej* (Warsaw), No. 7, 1955, pp. 87–96. 10 refs. In Polish, with summaries in English and Russian.

Kierunki Sprzężone w Ciele Anizotropowym (The Conjugate Directions in an

New Waldes Truarc locking-prong ring functions as spring, shoulder, fastener...and STAYS PUT!



Above assembly shows how 2 Waldes Truarc Locking-Prong Rings (Series 5139) replaced 6 parts...eliminated threading operation... and need for skilled labor.



WALDES TRUARC LOCKING-PRONG RING (Series 5139)
U. S. Pat. Pending

Ring No. 5139–	SHAFT Dia. S	tol.	RING DIMENSIONS A	tol.	B	tol.	C	tol.	E	tol.	H	tol.	T†	tol.†	average ultimate shear strength lbs.*	GROOVE DIMENSIONS Dia. G	tol.	Width W	tol. — .000	L min.	L max.	resilient end play take up L max– L min
12	.125	±.002	.340	±.010	.307	±.010	.166	±.005	.086	±.004	.050	±.010	.010	±.0013	400	.082	±.0015	.045	+.005	.035	.045	.010
★15	.156	±.003	.380	±.010	.330	±.010	.184	±.005	.108	±.004	.055	±.010	.010	±.0013	600	.104	±.002	.050	+.005	.035	.045	.010
18	.188	±.003	.445	±.010	.390	±.010	.213	±.005	.130	±.005	.060	±.010	.015	±.0015	900	.124	±.002	.065	+.005	.045	.055	.010
25	.250	±.003	.581	±.010	.500	±.010	.280	±.005	.172	±.005	.070	±.010	.015	±.0015	1000	.165	±.002	.070	+.005	.050	.065	.015
31	.312	±.003	.744	±.010	.620	±.010	.360	±.005	.234	±.005	.095	±.010	.018	+.001 −.002	1300	.228	±.003	.080	+.005	.080	.095	.015
★37	.375	±.003	.853	±.015	.740	±.010	.427	±.005	.280	±.005	.130	±.010	.020	±.002	1900	.270	±.003	.105	+.005	.090	.115	.025
★43	.438	±.003	.960	±.020	.820	±.020	.475	±.010	.337	±.010	.130	±.010	.020	±.002	2200	.327	±.003	.105	+.005	.095	.120	.025

Additional Sizes Under Development ★Production dies not available as of date of printing †Applies to unplated rings only *Recommended safety factor =3 to 4.

The Waldes Truarc Locking-Prong Retaining Ring is a new, low cost, radially applied fastener which can be locked positively in its groove and used as a shoulder against rotating parts. It is primarily intended for use in the automotive, electronic and aeronautical industries.

This radially applied ring locks positively in its grooves by means of two prongs at the open end. Because of its high thrust-load capacity the Waldes Truarc Locking-Prong Ring may be used as a shoulder against rotating parts. Its bowed construction provides for end-play take-up in the assembly and makes less critical the tolerances required for the parts being fastened. Since it serves as a spring as well as a shoulder, this ring eliminates the need for springs, washers, and other accessory fastening devices.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product...to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types...as many as 97 different sizes within a type...5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.

SEND FOR FREE SAMPLES

WALDES TRUARC® RETAINING RINGS

Waldes Kohinoor, Inc., 47-16 Austel Place, L.I.C. 1, N.Y.

☐ Please send me sample Locking-Prong Rings. (please specify shaft size_____)

☐ Please send me supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.

(Please print)

Name_____

Title_____

Company_____

Business Address_____

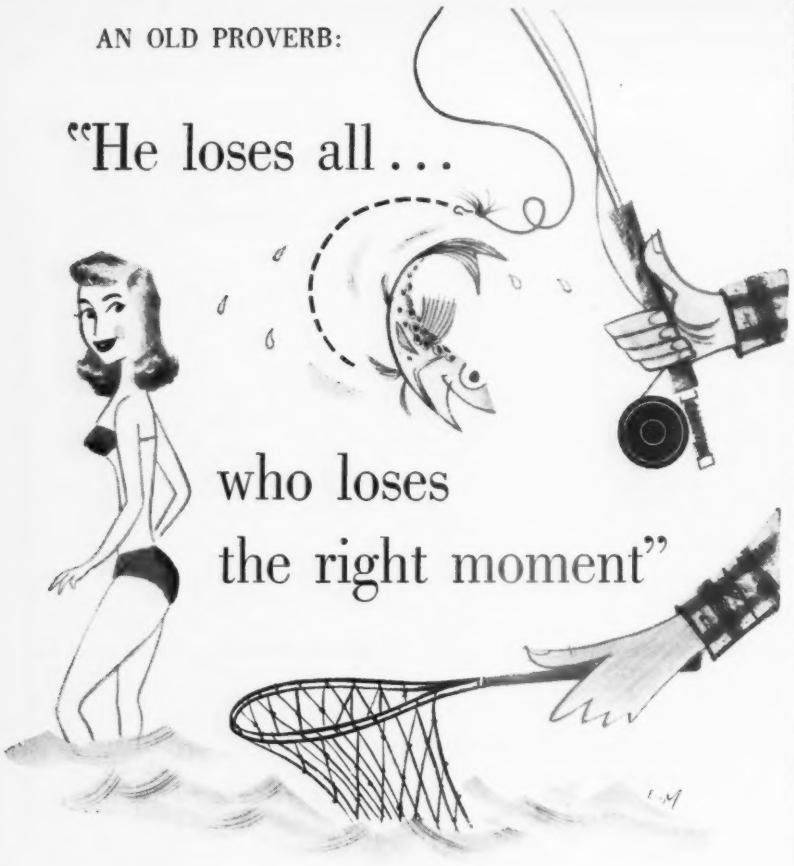
City_____ Zone_____ State_____

DEPARTMENT OF TECHNOLOGY BUFFALO AND ERIE COUNTY PUBLIC LIBRARY

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

AN OLD PROVERB:

"He loses all...



who loses
the right moment"

This is a good time to consider whether or not the moment has come for you to make the change in your employment that can mean the beginning of a successful, productive and happy future.

Opportunities are outstanding right now at Fairchild Aircraft Division, for experienced aerodynamists and designers looking for interesting, provocative work in the forefront of aviation design, research and development.

Take stock of your present job. See whether you wouldn't rather have the kind of progressive, active and interesting job that Fairchild is offering to the right men.

Send your resume today to Walter Tydon, Chief Engineer.

ENGINE AND AIRPLANE CORPORATION
FAIRCHILD
Aircraft Division
HAGERSTOWN, MARYLAND

"where the future is measured in light-years"

Anisotropic Body). Zbigniew Kączkowski. *Arch. Mech. Stosowanej* (Warsaw), No. 7, 1955, pp. 52–86. In Polish, with summaries in English and Russian. Development of a method for determining conjugate directions, with solutions applicable to orthotropic discs and plates.

Plasticity Coefficients for the Plastic Buckling of Plates and Shells. Alexander Krivetsky. *J. Aero. Sci.*, June, 1955, pp. 432–435. Use of carpet plots to evaluate the coefficients for five cases based on Bijlaard computations.

Podstawy Teorii Sprężystości ciał Fizykalnie Nieliniowych o Strukturze Niejednorodnej (Les Bases de la Théorie de l'Élasticité des Corps Physicalement Non-Linéaires à Structure Non-Homogène). W. Olszak and M. Życzkowski. *Arch. Mech. Stosowanej* (Warsaw), No. 7, 1955, pp. 151–168. 22 refs. In Polish, with summaries in French and Russian. Determination of equations based on the elasticity theory of isotropic bodies, physically nonlinear and of a nonhomogenous structure; applications.

Stress Functions of Elastic Bodies with Three-Dimensional Orthotropy. Z. Mossakowska. *Bul. Acad. Polonaise Sci.* (Warsaw), No. 1, 1955, pp. 3–6. 10 refs.

Plates

Deflection of Clamped Plates by Two-Step Membrane Analogue. V. Cadambe and R. K. Kaul. *J. RAeS*, May, 1955, pp. 358–360.

Investigation of the Post-Buckling Effective Strain Distribution in Stiffened, Flat, Rectangular Plates Subjected to Shear and Normal Loads. W. K. G. Floor. *Netherlands, NLL Rep. S.427*, July, 1953. 26 pp.

Rozwiązania Osobliwe dla Płyt Anizotropowych (Singular Solutions for Anisotropic Plates). Jerzy Mossakowski. *Arch. Mech. Stosowanej* (Warsaw), No. 7, 1955, pp. 97–110. In Polish, with summaries in English and Russian. With solutions applicable in particular cases to orthotropic and isotropic plates.

Singular Solutions for Anisotropic Plates. J. Mossakowski. *Bul. Acad. Polonaise Sci.* (Warsaw), No. 1, 1955, pp. 7–10.

Testing

The Outlook on Airframe Fatigue. (The Second Barnwell Memorial Lecture.) Walter Tye. *J. RAeS*, May, 1955, pp. 339–348. 10 refs. Developmental survey of structural component testing procedures and problems, optimum criteria for wing, pressure cabin, and tailplane tests, and potentialities for long-term improvements.

Testing Fatigue Life of Skin Panels. Edward Schiff. *Aero Dig.*, May, 1955, pp. 42, 44, 46. Convair equipment and technique using a simple water pressure system to yield rapid cyclization of test specimen, with an automatic cutoff at the failure point.

Thermodynamics

Variational Principles in Irreversible Thermodynamics with Application to Vis-

co-elasticity. M. A. Biot. *Phys. Rev.*, Mar. 15, 1955, pp. 1463–1469. Reprint.

Combustion

Equations of a Simple Flame Solved by Successive Approximations to the Solution of an Integral Equation. IV—Simple Ideal Flame Model Suggested by the HBr Flame. G. Klein. *U. Wis. NRL Dept. Chem. Rep. SQUID-3*, Apr. 18, 1955. 18 pp.

Formation and Combustion of Smoke in Laminar Flames. Rose L. Schalla, Thomas P. Clark, and Glen E. McDonald. (*U.S., NACA RM E51E15, RM E52G24, RM E52I22, RM E52I26, RM E53E05, RM E53J12, RM E54E03*, 1951–1954.) *U.S., NACA Rep. 1186*, 1954. 21 pp. 26 refs. Supt. of Doc., Wash. $0.25. Analysis of the basic nature and mechanism of smoke formation.

Heat Transfer

Effect of Pressure on Thermal Conductance of Contact Joints. Martin E. Barzelay, Kin Nee Tong, and George F. Holloway. *U.S., NACA TN 3295*, May, 1955. 52 pp. Experimental heat transfer measurements using 75S-T6 aluminum alloy and AISI Type 416 stainless-steel specimens.

Pin-Fin Heat-Exchanger Surfaces. W. M. Kays. *Trans. ASME*, May, 1955, pp. 471–478; Discussion, pp. 478–483. 11 refs. ONR-NavBuAer-Sponsored investigation of extremely high heat-transfer conductances, flow friction, and design criteria for high-performance cooling surfaces.

Vertical Take-Off Aircraft

Hovering Flight Tests of a Four-Engine-Transport Vertical Take-Off Airplane Model Utilizing a Large Flap and Extensible Vanes for Redirecting the Propeller Slipstream. Louis P. Tosti and Edwin E. Davenport. *U.S., NACA TN 3440*, May, 1955. 26 pp.

Safety Through Steep Gradient Aircraft; A Survey of the Status and Effects of Vertical and Near-Vertical Take-off and Landing. R. M. Woodham and Jerome Lederer. *Cornell-Guggenheim Av. Safety Cen.*, May, 1955. 75 pp. 33 refs.

Sul Decollo Verticale e Sulla Salita Verticale degli Aeroplani (On the Vertical Take-Off and Vertical Climb of Aircraft). Gaspare Santangelo. *L'Aerotecnica*, Feb., 1955, pp. 3–10. 11 refs. In Italian. Analysis includes hovering and climbing, static vertical flight ceiling, rate-of-climb, dynamic ceiling, and time-to-climb for turbojets and turboprops.

Water-Borne Aircraft

Recent Developments in the Hydrodynamic Design of Flying-Boats. J. H. Paterson. *J. RAeS*, May, 1955, pp. 349–355. Analysis includes the effect of planing bottom geometry on hull drag, spray characteristics, behavior in waves, maneuverability, and stability factors.

Wind Tunnels & Research Facilities

The Aerodynamic Laboratory at Vernon. P. Carrière. *Interavia*, No. 5, 1955, pp. 331–333. Description of the wind and firing tunnel facilities, test equipment, and techniques.

Design & Operation of an Intermittent 1″ x 3″ Supersonic Wind Tunnel. Satish Dhawan. *J. Aero. Soc. India*, Feb., 1955, pp. 1–17. Analysis includes selection of instrumentation and apparatus, flow visualization and recording systems, Reynolds Number control, and experimental techniques.

Instrumentation of a High-Pressure Supersonic Wind Tunnel. Frank B. Kroger. *ISA J.*, Feb., 1955, pp. 52–54. Design and operational characteristics, apparatus requirements, and problems of a supersonic blowdown type of tunnel with a 2–40 sec. stable operating period.

The N.R.C. Icing Wind Tunnels and Some of Their Problems. C. K. Rush. *Canada, NAE LR 133*, Apr. 19, 1955. 16 pp.

On the Calibration of Supersonic Wind Tunnels. Jacques A. F. Hill. *J. Aero. Sci.*, June, 1955, pp. 441–443. Method used at the MIT Naval Supersonic Lab., with typical curves for M = 3.5 and M = 7.0 nozzles.

Some Aerodynamic Studies in the Carde Aeroballistics Range. G. V. Bull. (*CAI 1st Annual Meeting, Toronto, May 19, 20, 1955, Preprint.*) *Canada, CARDE Misc. Rep. 53/55*, May, 1955. 41 pp. Detailed description of experimental facilities, apparatus, instrumentation, and techniques for dynamic and wind-tunnel tests.

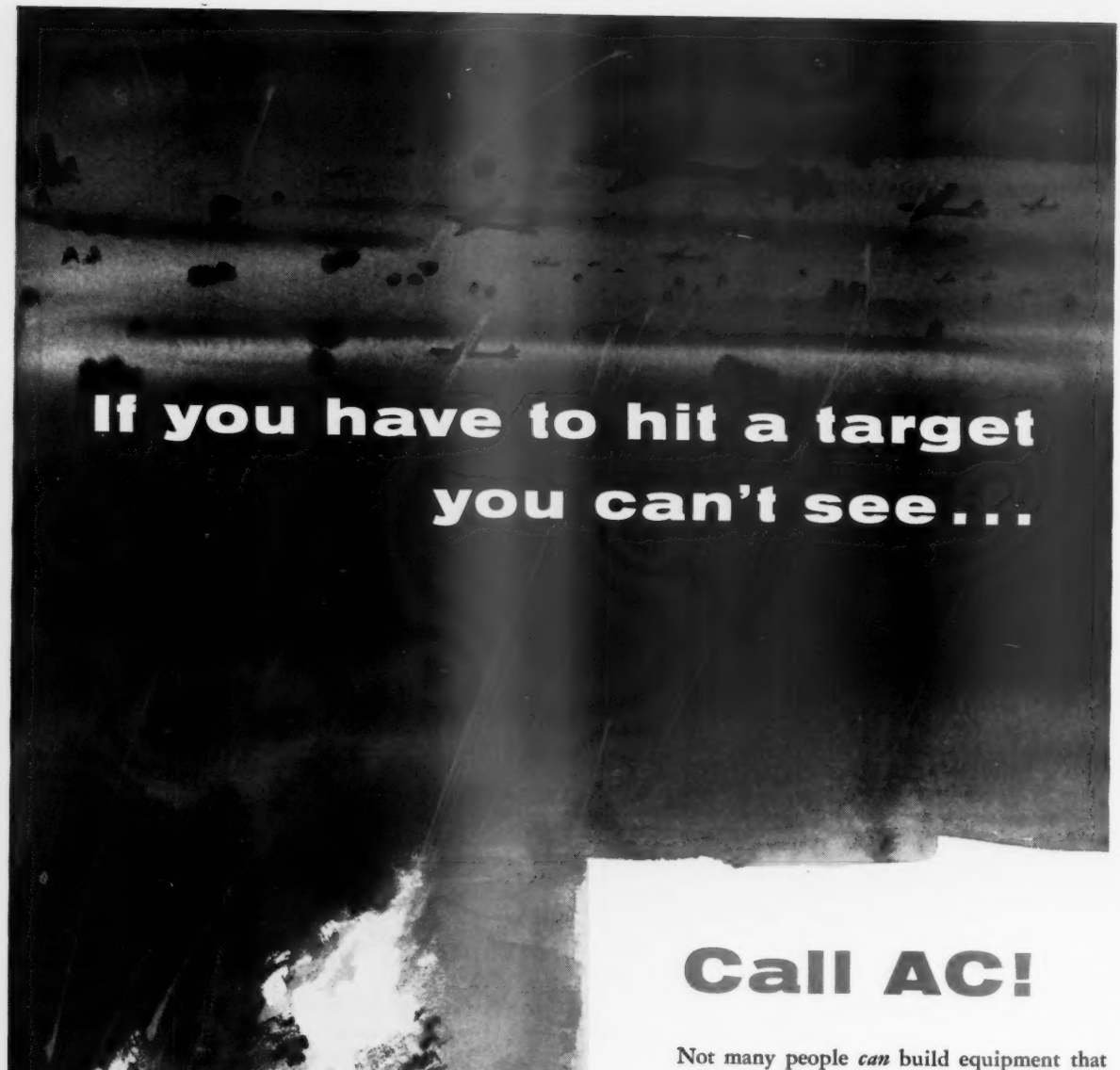
Tuyères Supersoniques a Col Réglable. M. Ménard and O. Monod. *France, Min. de l'Air NT 51*, 1955. 33 pp. In French. Study of design and performance of an experimental wind-tunnel nozzle with a sonic adjustable throat to solve speed and static longitudinal pressure variation problems.

Now Available

Reprints of Eighteenth Wright Brothers Lecture

"Fatigue Life of Airplane Structures" by Bo Lundberg, Director, The Aeronautical Research Institute (FFA), Sweden. (See Special IAS Publications, page 26.)

Member Price $1.00 Nonmember Price $1.50



If you have to hit a target you can't see...

Call AC!

Not many people *can* build equipment that will let you hit an unseen target in flight. As a matter of fact there are very few who are experienced in this highly complex field. But, AC stands high on the list.

The U.S. Army's Skysweeper is radar-directed and controlled by an amazing T-38 "electronic brain" built by AC. It not only detects and tracks intruders, it fires at them with devastating effect.

The deadly accuracy of the Skysweeper is one more step toward pinpoint fire-control methods . . . just one of many steps taken by AC.

If you have a problem in the field of fire control, call AC today!

AC DEFENSE PRODUCTS

Write for illustrated booklet "AC . . . Engineering for the Future"

AC now has several openings for qualified engineers in the electronics field. For detailed information, write to—

GM GENERAL MOTORS

AC SPARK PLUG DIVISION, GENERAL MOTORS CORPORATION
FLINT, MICHIGAN • MILWAUKEE, WISCONSIN

Aeronautical Reviews — BOOKS

The Dynamics and Thermodynamics of Compressible Fluid Flow, Vol. II

By Ascher H. Shapiro. New York, The Ronald Press, 1954. 1185 pp., illus., diagrs. $16.

This book is the concluding volume of a two-volume work, the first of which has been reviewed earlier (AERONAUTICAL ENGINEERING REVIEW, March, 1955). As in Volume I, Mr. Shapiro has maintained the step-by-step development of each facet of the subject under discussion. Such development is particularly helpful in the understanding of the more advanced aspects of the field presented in the second volume.

Volume II contains four parts—supersonic flow, mixed flow, unsteady motion in one dimension, and flow of real gases with viscosity and heat conductivity. The portion on supersonic flow is a continuation of the analysis of supersonic flow begun in Volume I, Part V. Introducing the case of axially symmetric supersonic flow, the author analyzes the exact equations for flow past a cone. Solutions given include Taylor-Maccoll numerical integration, Busemann hodograph graphical method, charts resulting from Kopal's integration by differential analyzer, and Kármán-Moore linearized theory. A discussion is presented on the "exact" solutions and on applications such as pressure drag of cones, comparison of cones and wedges, and use of the cone for supersonic diffusion. Experimental verification of the theoretical results is then presented. The accuracy of the linearized theory is next estimated by applying the results to flow about a cone and comparing them with the exact solution. The author also discusses several other approximate methods for flow about bodies of revolution—namely, second-order theory of Van Dyke, tangent-cone method, conical-shock-expansion theory of Eggers and Savin, and Newtonian theory. Charts are presented to illustrate variation in results among the solutions and also their variation from experimental results. Subsequently, the method of characteristics for axi-symmetric supersonic flows is introduced, and solutions are derived for both irrotational flow and flow with rotation. Examples are given of flows calculated by the method of characteristics. Particularly, the author explains application of the method of characteristics to supersonic nozzle design, and gives the Zienkiewicz empirical rule for simplifying the method as applied to pressure distribution on circular arc ogives. Typical experimental results are also given for flows about slender bodies which are not readily analyzed. These include static pressure probes and base pressure.

Mr. Shapiro next proceeds to the case of supersonic flow past wings of finite span. He demonstrates the method of determining regions of two-dimensional flow on various three-dimensional wings and defines "supersonic" and "subsonic" leading and trailing edges. The analysis first considers properties of infinite sweptback wings. Since the case of "subsonic" leading edge is, in effect, contained in Part IV, only the case of supersonic leading edge is handled here. The author derives two-dimensional wing coefficients that he relates to the actual sweptback case. Simplification of wing coefficient formulas through assumptions of thin profiles and small angle of attack is then shown. Effects of sweepback are discussed and illustrated.

The author next derives the similarity rule for supersonic wings which is followed by an explanation of the method of supersonic source and doublet distribution for calculating the flow past finite wings. Applications of this method are demonstrated for several plan forms, and the results are shown in accompanying figures. The comprehensive wave drag curves of Lawrence as calculated by the source distribution method for various wings are then given. The author also presents the method of conical fields for calculating the flow past finite wings. As a result of application of the above methods, the author presents a discussion and the curves of supersonic coefficients of rectangular wings, rectangular wings with raked tips, delta wings, and quadrilateral wings. Curves are also shown for comparison of theoretical results with experiment.

Hypersonic flow is dealt with as a separate regime. Approximations derived for supersonic flow which are not valid for very large Mach Number are first enumerated, and the approximate differential equation for hypersonic flow is derived. The author then is able to define a similarity rule for hypersonic flow and obtains formulas for the hypersonic force coefficients of a family of afinely related profiles. In analogous manner, similarity laws are outlined for bodies of revolution and wings of finite span. The special case of infinite Mach Number is analyzed. Effect of rotational flow on hypersonic similarity is next discussed, followed by a brief résumé of Van Dyke's similarity rule for both supersonic and hypersonic regimes. The author then evaluates the accuracy of the hypersonic small disturbance theory. This is followed by derivation of hypersonic oblique shock relations and simple wave expansion equations for hypersonic flow. Based on results of that derivation, Mr. Shapiro determines hypersonic performance of two-dimensional profiles. Several examples are shown in graphic form, and a simplifying approximation is given for the calculation of properties of various airfoils in hypersonic flow. Finally, hypersonic performance of bodies of revolution is studied. The similarity law for bodies is appraised by correlation with exact solutions of body pressure and force coefficients, and the range of applicability of the hypersonic similarity law is defined. This part of the book concludes with a discussion and graphic presentation of experimental results for wings, cones, cone-cylinders, and spheres. Clear, understandable photographs enhance the value of this section.

Part VI, mixed flow, begins with an investigation of certain mixed flow patterns by means of the hodograph method. The concept of limit line is then introduced, and the behavior of stream lines in the vicinity of the limit line is explained. A criterion for the appearance of a limit line is determined. The limit line as applied to the hodograph plane is next investigated, as are its physical relations to a flow. In addition, there are defined upper and lower critical Mach Numbers for a body immersed in a stream. Finally, a general solution of the hodograph equation by hypergeometric functions is indicated.

For information on IAS Library Service Facilities, see page 91.

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

The subject of transonic flow is next taken up. A transonic similarity law, analogous to the supersonic case, is discussed, and general remarks on similarity laws are presented. The author derives a transonic similarity law for two-dimensional flow past thin airfoils and presents results for axially symmetric flow and flow past wings of finite span. Effects of rotational flow and boundary conditions on the transonic similarity law are also treated. Applications of the transonic similarity law are then considered for cases of oblique shocks and Prandtl-Myer expansions, this leads to calculation of the transonic aerodynamic characteristics of flat plate airfoils and asymmetric wedge airfoils. Study of mixed flow is continued with analysis of steady shockless flow in the throat of converging-diverging nozzles. Both symmetric and asymmetric solutions of this analysis are explained and illustrated. Sauer's approximate rules for the shape of the sonic line in such a flow are derived, and their application to wind-tunnel design is noted. In addition, stages in development of supersonic flow in a convergent-divergent nozzle are explained. The relaxation method is then introduced and used in solving the problem of flow in two-dimensional nozzles with hyperbolic walls. Solutions are given for the special cases of transonic flow past a wave-shaped wall, of transonic pressure distribution, and of the lift and drag of two-dimensional symmetrical profiles. Experimental results for airfoil characteristics are shown for comparison.

Mr. Shapiro next analyzes typical transonic experimental results for reliability of the similarity law. This is followed by discussion of transonic experimental characteristics of wing profiles, wing plan forms, and bodies of revolutions. The mixed flow pattern found with detached shocks is studied, and the Moeckel method is given for location of both sonic point and position of the detached wave. Plotted experimental results are shown to correlate well with the results of the method. Subsonic-transonic flows with local shockless supersonic zones are analyzed, including effects of viscosity, and the stability of such flows is investigated. Interaction between boundary layers and shock waves in transonic flow is next considered and discussed briefly with the aid of some excellent schlieren photographs.

Part VII deals with unsteady motion in one dimension and is initiated with the derivation of governing differential equations for continuous, unsteady, one-dimensional flow with small perturbation from steady flow. Combining these equations and linearizing leads to a solution for waves of small amplitude. The result is supported by a simplified physical consideration of the problem and also by a method of characteristics approach. Linearized theory solution is then applied to a particular case that is utilized to explain reflection and intersection of waves.

Development of wave shape is also studied. Dropping the small perturbation restriction, the problem of large amplitude waves is analyzed both by extension of the linearized flow theory and by method of characteristics. After distinguishing among classes of flow patterns—steady state, simple wave, and double wave—the author explains generation of a wave and proceeds to analyze simple wave flow. This is followed by a method of characteristics construction of double wave flow. Operations involved in such construction are then classified and their application explained. These operations include intersection of waves, reflection of waves, outflow from and inflow to ducts, outflow and inflow through nozzles, change in duct cross-sectional area and incidence of waves on a temperature discontinuity. A calculation procedure based on the method of characteristics is then developed by the author for solving the general problem of unsteady viscous flow in a duct of varying cross section with heat transfer or combustion. He also discusses three possible procedures for working out problems using the method of characteristics and details advantages of each. This is followed by a summary of analogies between one-dimensional, unsteady motion and two-dimensional, steady, supersonic flow. At this point, examples of problems solved by the method of characteristics are discussed and pictured. Unsteady, one-dimensional shock waves are introduced in terms of the stationary shock formulas derived in an early chapter. Transformation to the moving shock case is shown, and the configuration of shock flows is explained. Shock relations for moving shocks are derived for both strong and weak shocks, and the shock polar for moving shocks is formulated.

Employing the foregoing discussions, the author analyzes the shock tube and presents a convenient working chart of results. Weak shock wave relations are next simplified, and the results are compared with a simple compression wave, which leads to a simplified calculation procedure for weak shocks. Examples of the simplified method are given for shock formation and shock and wave interaction. Since strong shocks are not amenable to the preceding method, the author modifies that method for processes not definable as "weak." These include reflections of shocks from tube ends and interaction of shock with shocks, with continuous waves, with contact discontinuities, and with area discontinuities.

Part VIII is concerned with the flow of real gases with viscosity and heat conductivity. A general discussion of both velocity and thermal boundary layer is followed by derivation of the laminar boundary-layer differential equations. After simplifying the equations by assuming Prandtl Number of unity, solutions are obtained for adiabatic flow and flow with zero pressure gradient and constant wall temperature. Howarth's investigation on the effect of adverse pressure gradient on laminar boundary-layer separation is then noted. The author next presents solutions in which Prandtl Number is not unity. For such cases, Van Driest's calculations provide numerous boundary-layer profiles on flat plates that are either insulated, heated, or cooled. The momentum integral method is given as an alternate method of solving boundary-layer problems. Discussion is given for the laminar boundary layer in axisymmetric flow, as an example of which relationships for cone-to-flat plate friction coefficients are stated. Numerous experimental curves are shown and compared with theoretical solutions of laminar boundary layer. Plots are given for velocity profiles, skin-friction coefficient, recovery factor, and heat-transfer coefficient. Analysis of laminar boundary layer is completed with discussion of its stability as affected both by Mach Number and heat transfer.

The study of turbulent boundary layer is next introduced and compared with the laminar case. After deriving differential equations of turbulent boundary layer, the simplification of Prandtl Number of unity is applied, and the resulting equations are given for flow past an insulated surface and flow past a flat plate at constant temperature. This is followed by consideration of the integral method of turbulent boundary-layer calculations, wherein definitions of displacement and momentum thicknesses are given. Recovery factor, skin friction, and heat-transfer calculations for flow past a flat plate with Prandtl Number unity are analyzed using derived equations. These calculations are reduced to specific results through the use of Prandtl's mixing length concept and Kármán's hypothesis of mechanical similitude. These results are then compared with experimental flat plate skin friction and drag measurements, and the experimental values are compared with various empirical formulas. Of particular interest are nomographic charts solving Van Driest's equations for the flat plate with heat transfer. Results of variation from Prandtl Number unity are analyzed, and comparison is made with experimental data. A useful summary of experimental results on recovery factors for various shapes is given. Extension of the integral method to calculation of turbulent boundary layer on bodies of revolution is demonstrated for a cone with attached shock and for a cylinder aligned with flow. In addition, experimental data for bodies of revolution are presented on the recovery factor, heat transfer, and transition.

Boundary layers of flow in tubes are next considered. The author discusses both subsonic and supersonic cases. Frictional effects for the laminar case are analyzed theoretically, and experimental results of the friction coefficient, recovery factor, and heat-transfer coefficient are given for both laminar and turbulent cases. Proceeding to the case of shock-boundary-layer interaction the author explains the physical significance of such a flow pattern. He first treats cases of oblique shock reflection from both laminar and turbulent flat plate boundary layers. This is followed by the case of generation of a shock in a concave corner, which is also

AERONAUTICAL ENGINEERS AERODYNAMICISTS

Openings are available for Wind Tunnel Test Engineers to work in two supersonic wind tunnels and one hypersonic wind tunnel (under construction) as Test Project Engineers. Duties include responsibility for pre-test planning, calibration, test supervision, data reduction and report preparation.

This is an unusual opportunity to participate in diversified types of tests and to gain experience in testing techniques, use of electronic test equipment, IBM and electronic data handling and computing, automatic machine plotting, etc.

Present work week 48 hours (5 days) with overtime compensation.

Airmail your summary of qualifications to:

CALTECH
JET PROPULSION LABORATORY
4800 Oak Grove Drive
Pasadena 3, California

THE WORLD'S LARGEST PRODUCER OF READY-TO-INSTALL POWER PACKAGES FOR AIRPLANES INVITES YOU TO ENJOY YOUR WORK *AND* YOUR LIFE IN *beautiful* SOUTHERN CALIFORNIA

We believe we can offer you an opportunity to improve your position in the business world – and improve your way of life here at Rohr Aircraft Corporation in beautiful, temperate, exciting Southern California. To strengthen our personnel in various departments, Rohr has a real opportunity for you if you are skilled as an –

ENGINEER (Aircraft Design or Structures) LOFTSMAN
JIG & FIXTURE BUILDER TOOL PLANNER TOOL DESIGNER

ROHR
AIRCRAFT CORPORATION

Please write giving complete details and we will answer immediately.

Mr. Ned DeWitt, *Personnel Department 38*
Rohr Aircraft Corporation
Chula Vista, California

9 miles south of San Diego on sunny San Diego Bay.

Consult your

1955 AERONAUTICAL ENGINEERING CATALOG...

for suppliers of aircraft parts, materials, and services

- A master file of company product catalogs.
- 25,000 listings to vendors of over 2,000 aircraft and guided missile materials and components.
- Names, current addresses and general description of products of all principal manufacturers.
- Handy inquiry postcards.

AN OFFICIAL PUBLICATION:

INSTITUTE OF THE AERONAUTICAL SCIENCES
2 E. 64th St. New York 21, N.Y.

An Opportunity

IN MISSILE RESEARCH

We are seeking men of high analytical ability to assume challenging responsibilities on a variety of research work related to classified missile projects.

Background in mathematical methods of physics is essential. M.A. or Ph.D. in Physics or Math is desirable.

CORNELL AERONAUTICAL LABORATORY, INC.
BUFFALO 21, NEW YORK

ENGINEERS

THE APPLIED PHYSICS LABORATORY OF THE JOHNS HOPKINS UNIVERSITY offers an exceptional opportunity for professional advancement in a well-established Laboratory with a reputation for the encouragement of individual responsibility and self-direction.

Our program of

GUIDED MISSILE RESEARCH and DEVELOPMENT

provides such an opportunity for men in:

SUPERSONIC MISSILE DESIGN
WIND TUNNEL TESTS AND DATA ANALYSIS
RAMJET DESIGN AND ANALYSIS
MISSILE SYSTEMS DEVELOPMENT
DESIGN AND LAYOUT OF MISSILE COMPONENTS
RESEARCH AND ANALYSIS IN AERODYNAMIC STABILITY & CONTROL

Please send your resume to:
Professional Staff Appointments

APPLIED PHYSICS LABORATORY
THE JOHNS HOPKINS UNIVERSITY
8621 Georgia Avenue
Silver Spring, Maryland

discussed for both laminar and turbulent boundary layer. Finally, there is presented a discussion of the case of shock generation by a wedge. The case of shock-boundary-layer interaction in transonic flow receives special attention. This exceptionally well-illustrated section concludes with analysis of normal shock-boundary-layer interaction in ducts and boundary-layer separation produced by shock waves. Application of results noted in this section to supersonic diffusers is pointed out.

In spite of the complexity of the advanced subjects collected in this volume, Mr. Shapiro has managed a rather complete coverage of the field. It is felt, however, that additional sections on wing-body interference and on noncontinuum flow are within the scope of the work and would have enhanced the value of this contribution. Moreover, there is a somewhat overdependence upon references for details, such as, ". . . the reader is referred to Reference 30 for full details of the analysis . . ." (Van Dyke's second-order theory); or ". . . (see Reference 1, for example) . . ." (simplification of the differential equations of the laminar boundary layer by use of the order of magnitude assumptions). Such statements helped to create the impression upon the reviewer that the author was trying to compress the material to fit into a single book and that the second volume should, perhaps, have been split into two volumes.

All in all, the reviewer feels that the second volume, although not as detailed as the first, completes a work that is outstanding in its field, thus warranting its inclusion in the library of the practicing scientist or advanced student.

HAROLD L. BLOOM
Guided Missiles Department
General Electric Company

Book Notes

ELECTRONICS

Aeronautical Electronics Digest: A Compendium of Technical Papers Exemplifying Progress in the Field of Aeronautical Electronics, presented at the National Conference on Aeronautical Electronics, May 9–11, 1955, Dayton, Ohio. Dayton Section, Institute of Radio Engineers, 1955. 422 pp., illus., diagrs., figs. $4.00.

This is the fourth volume of technical papers to be published in conjunction with the annual National Conference on Aeronautical Electronics. The present volume has been standardized along the lines of the 1954 volume that was entitled *Airborne Electronics Digest*. It contains 108 papers.

FUELS AND LUBRICANTS

Basic Lubrication Practice. Allen F. Brewer. New York, Reinhold Publishing Corporation, 1955. 286 pp., illus., diagrs., figs. $6.75.

This book is intended for lubrication and maintenance engineers, executives, operators, and students as a guide to the selection and use of lubricants for industrial and power-plant machinery. The author was formerly editor of *Lubrication*, a position he held for 32 years while serving as Engineering Technologist with the Technical and Research Division, Refining Department, The Texas Company.

Contents: 1, The Operating Conditions Affecting Lubrication. 2, Physical Tests of Petroleum Lubricants and Their Significance. 3, Plain or Sleeve-Type Bearings and Cams. 4, Bearing Materials. 5, Ball and Roller Bearings. 6, Thrust Bearings. 7, Gears. 8, Chains. 9, Wire Rope Lubrication. 10, Flexible Couplings. 11, Methods of Sealing. 12, Automatic Lubrication. 13, Rust Preventive Lubricants. 14, Steam Turbine Service. 15, Steam Cylinder Lubrication. 16, Internal Combustion Engine Oils. 17, Power Plant Auxiliaries. 18, The Electric Motor. 19, Air Compressors and Pneumatic Tools. 20, Refrigeration Compressor Lubrication. 21, Hydraulic Power. 22, Careful Storage and Handling Prevents Contamination. 23, Lubricating Oil Reconditioning. 24, Nonpetroleum Lubricants.

RESEARCH

Coordination, Control, and Financing of Industrial Research; Proceedings of the Fifth Annual Conference on Industrial Research, June, 1954, with Selected Papers from the Fourth Conference, June, 1953. Sponsored by the Department of Industrial Engineering, Columbia University. Albert H. Rubenstein, Editor. New York, Columbia University Press, 1955. 429 pp., diagrs., figs. $8.50.

Contents: The Current Status of Industrial Research, David B. Hertz. Coordination of Research with the Financial Aims of the Company, Denis M. Robinson. Coordination of Research with Sales, Edward L. Kropa. New Product Innovation and Introduction: Their Broad Implications, W. Rupert Maclaurin. Management of Industrial Research, E. D. Reeves. Internal Control of Research Operations, Edwin Pike. Coordination of Research with the Quality Objectives of the Company, C. L. Rumberger. Frontiers of Statistical Quality Control, Sebastian B. Littauer. The Economic Future of Industrial Research, Yale Brozen. The Control of Research Funds, Fred Olsen. Economics of Industrial Research, E. Finley Carter. The Art of Business Forecasting and Its Use, Courtney C. Brown. Top Management—Senior Partner in Research, Michael Watter. The Influence of Capital Availability on Research Policy, C. E. Waring. Translating the Economic Aspects of Company Policy into Research Policy, Ralph H. Manley. Preparation of Research Budgets and the Control of Research Expenses, J. H. Bentley, Jr. The Philosophy of Research Budgeting and Cost Control, V. N. Morris. Some Key Questions for the Research Administrator, Robert N. Anthony. Building Better Management-Research Relationships, Charles W. Kaufman. Evaluating the Cost and Utility of Industrial Research and Development, W. I. McNeil. The Research Revolution, David B. Hertz. What Military Research and Development Mean to Industry, Donald A. Quarles. The Importance of Experimental Design in Efficient Experimentation, E. Bright Wilson, Jr. Research Project Evaluation, Merrill M. Flood. Introduction to Computer Technology, C. B. Tompkins. Application of High Speed Computers to Research Problems, Richard F. Clippinger. Automatic Data Reduction, G. Truman Hunter. Operation of an Industrial Computing Facility, H. R. J. Grosch. Clinic Session Discussions.

SAFETY

Safety Through Steep Gradient Aircraft; A Survey of the Status and Effects of Vertical and Near-Vertical Take-Off and Landing. R. M. Woodham and Jerome Lederer. New York, The Daniel & Florence Guggenheim Aviation Safety Center at Cornell University, May, 1955. 75 pp., illus., diagrs., figs. $1.00.

A survey of the present state of development, emphasizing the consequences for safety inherent in the idea of steep gradient approach and take-off. The authors are Associate Director and Director, respectively, of the Cornell-Guggenheim Aviation Safety Center.

TELEMETERING

National Telemetering Conference, 1955; The Complete Papers of the Conference Held at Chicago, May 18–20, 1955. Sponsored by the American Institute of Electrical Engineers, the Institute of the Aeronautical Sciences, the Institute of Radio Engineers, and the Instrument Society of America. New York, 1955. 211 pp., illus., diagrs., figs. $3.50. Available from the Institute of the Aeronautical Sciences, Inc., 2 East 64 Street, New York 21, N.Y., and also from the other sponsoring organizations.

Contents: Components I—Industrial Telemetering: A New Hi-Speed Telemeter Transmitter for DC Measurements, R. M. Stuart. An Incremental Remote Position Control System, Jonathan Mass. Systems I—Industrial Telemetering: A New Time Interval Telemeter System, W. H. Howe. Automatic Teletype Transmitting System, J. R. Cunningham. Ultra Sonic Liquid Level Indicating Systems, R. L. Rod. Channels for Telemetering, Supervisory Control and Other Purposes, H. A. Rhodes and R. W. Ralston. Mechanical Sampling Devices in Telemetering and Related Fields, J. F. Brinster. Components II—Pick Ups and Transducers: Vibrotron Digital Telemetering System, J. Ohman. A Commutatorless Direct Current Motor, H. D. Brailsford. Precision Data Recording and Repeating System (The Inductosyn), J. L. Winget. A Phase Modulated Transistorized Pressure or Acceleration Telemetering Channel, A. I. Dranetz and J. L. Upham. New Developments in Miniature Telemetering Pickups, L. A. G. TerVeen. Systems II—Flight Testing: Range and Coverage Characteristics of a High Capacity PTM-AM Telemetering System, J. E. Spooner. Telemetry as a Flight Test Instrument, J. J. Dover. A PDM-FM Telemeter for Low Lever DC Inputs, R. W. White. An Analog Cross-Spectrum Analyzer for Certain Telemetered Data, R. L. Kenimer. A Capacitance Compensated Strain Gage Subcarrier Oscillator, R. A. Runyan and J. B. Harry. Systems III—Multiplexing Techniques: A New Subminiature Airborne FM Demultiplexer, L. Finkel, F. Shandelman, and J. Piontkowski. The Magnetron Beam Switching Tube, H. Moss. High Speed Mercury Jet Commutating Switch, W. R. Davis. Miniaturized Airborne Electronic Commutator, R. O. DuBois. Telemetry Filters and Their Effect on the Dynamic Accuracy of Multiplex FM Subcarrier Instrumentation Systems, G. S. Sloughter, R. A. Runyan, W. H. Duerig, and G. E. Tisdale. Components III—New Developments in Telemetry and Remote Controls: Mixing Airborne Telemetering Subcarriers for Maximum Isolation with Minimum Loss, W. F. Link. A New Crystal-Controlled Ground-Station Telemetering Receiver, M. S. Redden, Jr., and H. W. Zancata. A New Instrumentation Direct Writing Recorder and Its Application to Telemetry, G. E. Bower. Precision Multi-Channel Heads for Magnetic Tape Recording, A. V. Gangnes. A Digital Approach to Telemeter Testing, C. R. Reid. Evaluation of an Automatic Landing System for Aircraft, M. H. Goldstein, Jr., and C. W. Merriam, III. Systems IV—New Developments in Telemetry and Remote Control: Radar Beacon Telemeter, J. W. Poliseo. A 14-Channel System for Remote Control of Aircraft Flight, W. H. Eggerton. A Pulse Telemetering System for Use on Balloon-Launched Rockets, L. R. Davis. A Sequential Pulse Telemetering System, T. B. Jackson. Silicon Transistor Applications in Telemetering Equipment, C. E. Earhart and O. A. Becklund. Coherent Pulse Telemetry, A. H. Cooper. Components IV—Data Processing: The Role of Magnetic Tape in Data Recording Processing and Analysis, G. L. Davis. Taking to a Computer, R. F. Shaw. A Precision Pressure Telemetering System with Digital Data Handling, J. Prast, S. H. Calhoun, G. S. Hartloff, and G. W. Liske. An Automatic Digital Telemetering System for Small Guided Missiles, R. F. Hummer, R. M. McClung, and D. J. Simmonds. Automatic Data Reduction of Missile Telemetering, H. D. Greif and R. A. DeKimpe.